Report on Trials Evaluating Additional Measurements

FINAL REPORT MARCH 2004

REPORT ON TRIALS EVALUATING ADDITIONAL MEASUREMENTS

March 2001 – March 2004

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1. SUMMARY OF THE REPORT

The TEAM-3 Processing Trial commenced in March 2001 and concluded in March 2004. At the conclusion of the trial, 34 mills had submitted a total of 647 commercial processing consignments. This report summarises the final analysis of the TEAM-3 database.

The principal conclusions of the TEAM-3 Processing Trial are as follows:

- The TEAM-2 parameters (Staple Length, Staple Strength, Mean Fibre Diameter, Vegetable Matter Base, and Adjusted Mid-Breaks) are still applicable to processing prediction models.
- Processing performance has improved since the late 1980's. Mills are producing tops with Hauteur values, on average, 5.1mm longer than is predicted using the TEAM-2 general formula. Greater differences occur as the actual Hauteur increases above 75mm. In addition, mills are producing tops with Coefficient of Variation of Hauteur (CVH) values, on average, 2.5% less than predicted by TEAM-2 and Romaine values 2.1% greater than predicted. These differences were similar for all of the five processing regions examined (Australia, China, India, Europe, and Other Asia).
- The Core/Comb relationships show that the average Mean Fibre Diameter of the processed top is 0.20µm higher than the Mean Fibre Diameter of the greasy wool, whilst the Coefficient of Variation of Diameter is 0.9% lower in the top. The actual processing yield of the TEAM-3 consignments is, on average, 1.1% higher than that predicted by the Schlumberger Dry Top & Noil Yield formula.
- Mills that participated in TEAM-3 achieved more consistent results with lower standard deviations between the actual and predicted Hauteurs than those mills who participated in TEAM-2.
- The regression analyses for Hauteur, CVH and Romaine have shown that it is possible to calculate new General Formulae for these parameters. It is also shown that the raw wool variables from the TEAM-2 General Formulae are still integral to the processing prediction model.
- For Hauteur, the additions of Coefficient of Variation of Diameter (CVD) and Coefficient of Variation of Length (CVL) provide small improvements to the prediction model. The use of Mid-Breaks (M) instead of Adjusted Mid-Breaks (M*) makes little change to the prediction model coefficients and has the benefit of simplifying the formula. It has been observed that there is no improvement in processing prediction if Mean Fibre Curvature (MFC) is included in the prediction model. The analysis of the TEAM-3 database has found that VM does not significantly influence the prediction of Hauteur. However due to the relatively narrow VM range in the TEAM-3 database, the inclusion of the VM coefficient from the TEAM-2 prediction formula for Hauteur is recommended. A revised Hauteur formula is proposed based on the analysis of the TEAM-3 database.
- For CVH, the addition of CVL provides a small improvement to the prediction model. It has been identified that there is no improvement in processing prediction if either MFC or CVD is added to the prediction model. The use of M instead of M* makes little change to the prediction model and has the benefit of simplifying the formula. A revised CVH formula is proposed based on the analysis of the TEAM-3 database.
- For Romaine, it has been identified that there is no improvement in processing prediction if either CVL, CVD or MFC is added to the prediction model. A revised Romaine formula is proposed based on the analysis of the TEAM-3 database.
- As was identified in the TEAM-2 report (1988), significant processing differences were identified between the individual mills participating in TEAM-3. Mills need to establish their own database and develop their own prediction formulae by using the recommended General Formulae and subsequently determining and reviewing an appropriate constant adjustment to the mill factor. Mills should consider fine tuning the formulae for particular categories or types of wool and topmakers who comb at more than one mill should also consider adjustments for each mill.

Based on the analysis of the full TEAM-3 database, the TEAM-3 Steering Committee recommends that the industry consider the following three options:

Option 1. Retain the existing TEAM-2 General Formulae in the IWTO Staple Test Regulations.

Option 2. Introduce new TEAM-3 General Formulae into the IWTO Staple Test Regulations as a replacement for the TEAM-2 General Formulae. The recommended formulae are as follows:

Hauteur = 0.43L + 0.35S + 1.38D – 0.15M – 0.45V – 0.59CVD – 0.32CVL + 21.8

CV Hauteur = 0.30L – 0.37S – 0.88D + 0.17M + 0.38CVL + 35.6

Romaine = – 0.13L – 0.18S – 0.63D + 0.78V + 38.6

Option 3. Include both the TEAM-2 General Formulae and TEAM-3 General Formulae in the IWTO Staple Test Regulations.

2. INTRODUCTION

It is well recognised that the prediction of processing performance is important since it allows individual mills to optimise raw wool inputs to meet desired outcomes in the top and it provides mills with a useful quality management tool.

For many years the Trials Evaluating Additional Measurement (TEAM) formulae, which utilise measurements of Staple Length & Staple Strength, have been the industry benchmark for the prediction of Hauteur (average fibre length in the top), Coefficient of Variation of Hauteur and Romaine (fibre wastage). The TEAM-1 and TEAM-2 projects concluded in 1984 and 1988 respectively and since that time there have been a number of attempts to improve the prediction of processing performance. However, a survey conducted in 1997 (Douglas & Couchman) clearly showed that the TEAM formulae remain the generally recognised world benchmarks. While this survey showed general satisfaction with the current TEAM formulae, it did reveal some limitations. Nevertheless, the use of the TEAM formulae as a benchmark has enabled individual mills to improve processing performance significantly. Due to the shortage of industry funds, research to improve the prediction model has been left to individual topmakers and their customers.

The introduction of Laserscan in July 2000 as the standard for all Presale Fibre Diameter tests in Australia, and the availability of Staple Length & Staple Strength data on most combing lots in sale catalogues, provided both a catalyst and an opportunity to review the TEAM-2 predictive formulae at minimal cost. It has been suggested that the new measurements provided by Laserscan, such as Coefficient of Variation of Diameter (CVD) and Mean Fibre Curvature (MFC), may influence top making performance. If so, their inclusion in the TEAM formulae may improve the accuracy of predicting such performance.

In March 2001, at the Shanghai meeting of the International Wool Textile Organisation (IWTO), the Australian Wool Testing Authority Ltd (AWTA Ltd) announced the commencement of the TEAM-3 trial. The TEAM-3 Processing Trial was co-ordinated by the TEAM-3 Steering Committee. The members of this Committee were as follows:

Michael Jackson	**Managing Director, AWTA Ltd**
Ian Ashman	**General Manager Customer Relations, AWTA Ltd**
Jim Marler	**National Technical Advisor, AWTA Ltd**
Andrew Lindsay	**Sampling Operations Manager NSW/QLD, AWTA Ltd**
Trevor Mahar	**Research Manager, AWTA Ltd**
Bob Couchman	**Capronex Services Pty Ltd**

In addition to the above TEAM-3 Committee members, Victoria Fish and David Crowe, from AWTA Ltd's Research and Development Division, assisted with the statistical analysis of the TEAM-3 database and the interpretation of results.

During the three year duration of the TEAM-3 trial, four successive progress reports were presented to the International Wool Textile Organisation (IWTO) providing an update on its progress (Lindsay et al, 2002a; Lindsay *et al*, 2002b; TEAM-3 Steering Committee, 2003; and, Lindsay *et al*, 2003). A final report was presented to the Raw Wool Group of IWTO on the 10th of May 2004 in Evian, France.

This report is similar to the paper presented at Evian in May 2004, however additional detail has been provided and comments from participants at the Evian Meeting have been incorporated into the report.

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3. TEAM-3 CONSIGNMENT CHARACTERISTICS

3.1 Bale and Lot Details

Processing consignments suitable for inclusion in TEAM-3 were accepted from March 2001 until March 2004. At the conclusion of consignment receival, 34 mills had submitted a total of 647 commercial consignments. The composition of both the TEAM-2 and TEAM-3 databases, in terms of the number of bales and lots, is shown in Table 3.1.

The 603 consignments submitted for the TEAM-2 trial comprised the total database that was used to derive the TEAM-2 General Formulae. This included data from the TEAM-1 and TEAM-2 projects as well as additional mill data (see TEAM-2 report, 1988).

TABLE 3.1

COMPOSITION OF THE TEAM-2 AND TEAM-3 CONSIGNMENTS

	TEAM-2	TEAM-3
Number of consignments	603	647
Total number of bales	88,000	159,000
Bales per consignment – Average	– –	246
Bales per consignment – Range	– –	44 to 1568
Lots per consignment – Average	17	40
Lots per consignment – Range	3 to 80	3 to 254

The global distribution of the processing mills that participated in TEAM-3 is illustrated in Table 3.2. Previous TEAM-3 progress reports have indicated that 37 mills signed an agreement to participate in the trial. However, Table 3.2 lists only 34 participating mills or topmakers because some of those who signed an agreement were unable to submit consignments. The effects of the 2002/03 drought in many parts of Australia, and general wool market conditions resulted in some participants having difficulty sourcing consignments that met the requirements for inclusion in the TEAM-3 trial. The number of consignments submitted by each mill or topmaker ranged from 1 to 33 with an average of 19 consignments.

For a consignment to be accepted as part of the TEAM-3 trial, several requirements had to be met:

- Each consignment contained a minimum of 100 bales of greasy wool (*Note: a small number of specialty superfine consignments were accepted despite being less than 100 bales*);
- Every lot in each consignment was tested for Fibre Diameter using Laserscan technology (IWTO-12);
- 95% of each consignment (by nett weight) had been certified for Staple Length & Staple Strength (IWTO-30);
- The mill provided Test Certificate information and processing information for each consignment submitted (see example proforma in Appendix 1); and
- The mill submitted to AWTA Ltd five (5) lengths of twisted top (as per IWTO-17) which were taken randomly from each processing batch. These samples were tested by AWTA Ltd to provide a common measurement basis for the entire database.

TABLE 3.2

TEAM-3 PARTICIPANTS

Australia
Australian Topmaking Services Ltd
Fletcher International Exports Pty Ltd
Geelong Wool Combing Ltd
GH Michell & Sons (Aust) Pty Ltd
Lempriere (Australia) Pty Ltd
Port Phillip Wool Processing Pty Ltd
Riverina Wool Combing Pty Ltd

Czech Republic
Nejdek Wool Combing, A.S.

Korea
Cheil Industries Inc

Singapore
Nankai Worsted Spinning Co Ltd

Taiwan
Reward Wool Industry Corporation

China
Australia Harvest Wool Textile Co Ltd
Jiangsu Changzhou Tops Mill
Jiangsu Sunshine Group
Lanzhou Sanmao Textile Group Co Ltd
Reward (Ningbo) Wool Industry Co Ltd
Shanghai No 1 Topmaking Company
Wuxi Xie Xin Group
Zhangjiagang Free Trade Zone – Concord Wool Textile Industrial Co Ltd
Zhangjiagang Free Trade Zone – Tianyu Woollen Textile Co Ltd
Zhangjiagang Yangtse Wool Combing Co Ltd
Zhejiang Xinao Group

France
Peignage de la Tossée
Ets A Dewavrin Fils & Co

India
Global Wool Alliance Pty Ltd
Indoworth India Limited
Jayashree Textiles Unit
Oswal Woollen Mills Ltd
Raymond Limited

Italy
Pettinatura Europa 90 S.r.l.
Vitale Barberis Canonico S.P.A.

Slovak Republic
Merina j.s.c

Thailand
Indorama Group

Japan
Nippon Keori Kaisha Ltd

3.2 Raw Wool and Top Characteristics

A summary of the major raw wool and processing characteristics of the TEAM-2 and TEAM-3 databases are presented in Tables 3.3 and 3.4 respectively. The consignments submitted by TEAM-3 participants represent current commercial processing blends. Apart from the requirement that 95% of the consignment was additionally measured, the selection of consignments for the TEAM-3 trial was entirely at the discretion of the mill (or topmaker). Although participants were encouraged to find consignments with a wide range of raw wool attributes, commercial realities and practicalities limited the ability of mills to provide such consignments. The average fleece wool component of the consignments was approximately 90%; however there were a number of 100% skirting wool consignments submitted.

Histograms of the major raw wool and processing characteristics depicted in Tables 3.3 and 3.4 are shown graphically in Figures 3.1 to 3.12.

TABLE 3.3

RANGE AND MEAN OF THE AVERAGE RAW WOOL CHARACTERISTICS OF CONSIGNMENTS

	TEAM-1 & TEAM-2 Database			TEAM-3 Database		
	Avg	Min	Max	Avg	Min	Max
Schlum Dry Yield (SDRY) (%)	–	–	–	68.8	56.1	78.1
Mean Fibre Diameter (µm)	22.0	17.4	31.0	20.1	16.3	25.1
CV of Diameter (%)	–	–	–	22.0	19.1	28.1
Comfort Factor (%)	–	–	–	97.2	80.7	99.5
Mean Fibre Curvature (deg/mm)	–	–	–	94	74	120
Vegetable Matter Base (%)	2.1	0.1	10.2	1.2	0.3	5.3
Staple Length (mm)	86	59	123	85	64	104
CV Length (%)	19	12	30	18	14	30
Staple Strength (N/ktex)	39	23	60	38	24	51
Tip Breaks (%)	–	–	–	21	2	57
Mid-Breaks (%)	38	2	88	52	28	86
Base Breaks (%)	–	–	–	27	5	66

TABLE 3.4

RANGE AND MEAN OF THE AVERAGE PROCESSING CHARACTERISTICS OF CONSIGNMENTS

	TEAM-1 & TEAM-2 Database			TEAM-3 Database		
	Avg	Min	Max	Avg	Min	Max
Hauteur (mm)	66.6	48.0	96.8	72.0	56.3	91.0
CVH (%)	48.9	31.1	60.7	44.9	32.5	58.2
Romaine (%)	7.6	1.0	21.0	9.3	2.3	19.5
Top & Noil Yield (%)	64	46	77	69.9	58.2	92.8
Mean Fibre Diameter (µm)	22.1	17	31	20.3	16.3	25.4
CV of Diameter (%)	–	–	–	21.0	17.3	26.3
Comfort Factor (%)	–	–	–	97.1	82.8	99.8

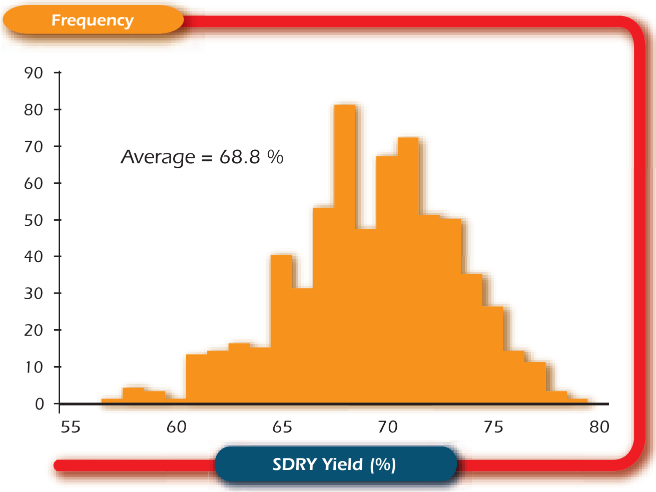

Figure 3.1 SDRY Yield Histogram

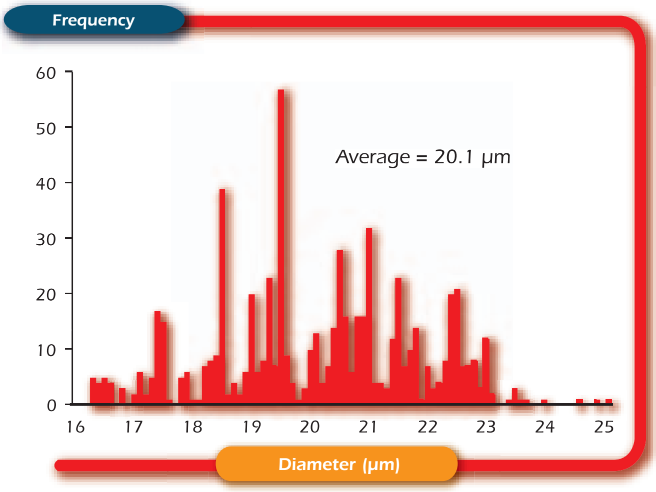

Figure 3.2 Mean Fibre Diameter Histogram

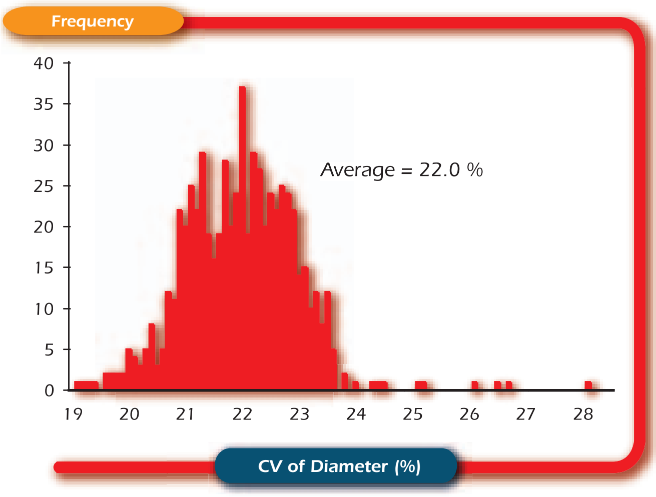

Figure 3.3 CV of Diameter Histogram

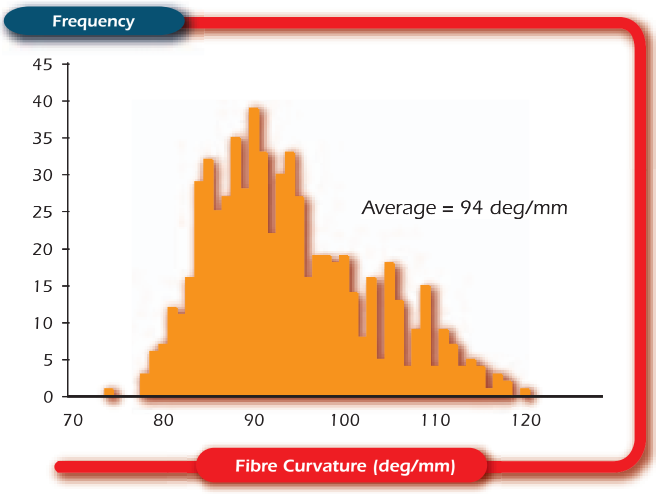

Figure 3.4 Mean Fibre Curvature Histogram

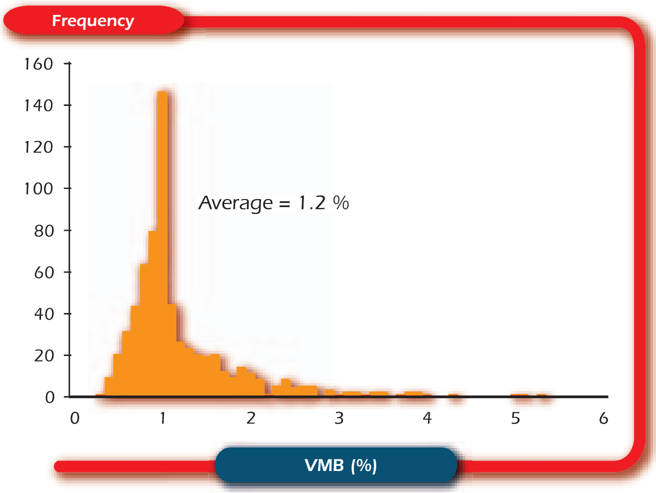

Figure 3.5 Vegetable Matter Base Histogram

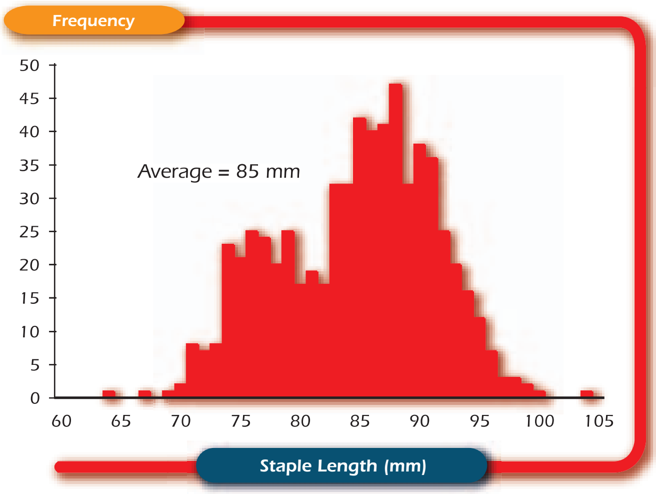

Figure 3.6 Staple Length Histogram

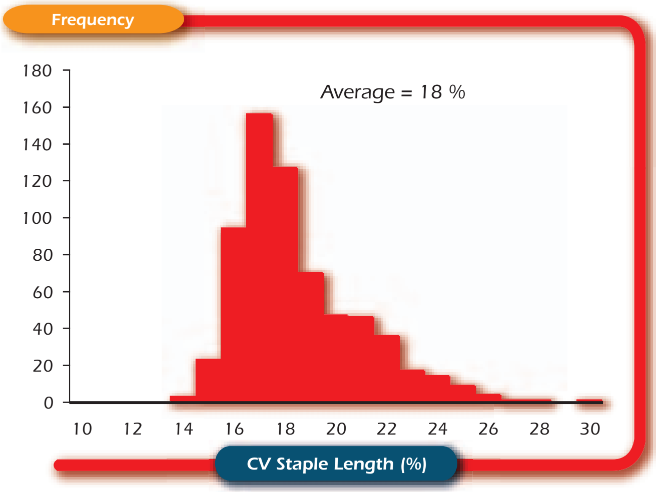

Figure 3.7 CV Staple Length Histogram

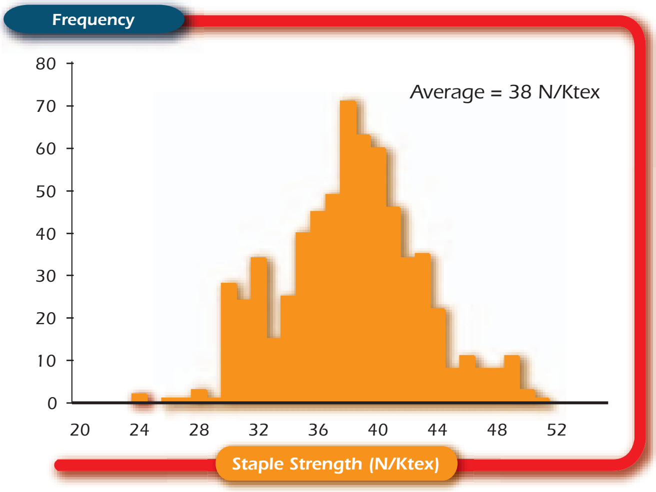

Figure 3.8 Staple Strength Histogram

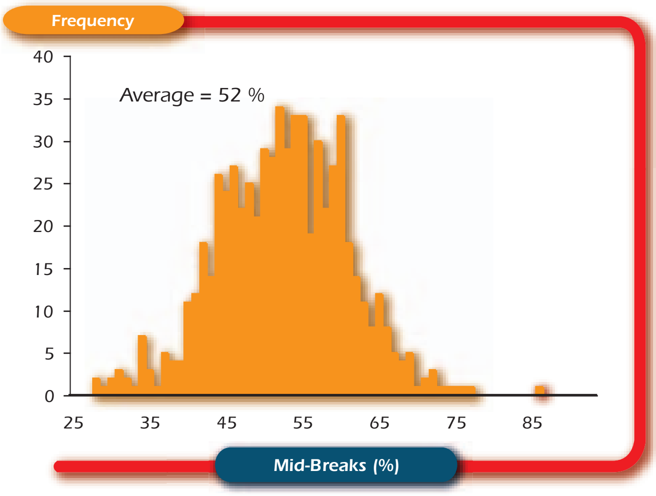

Figure 3.9 Mid-Breaks Histogram

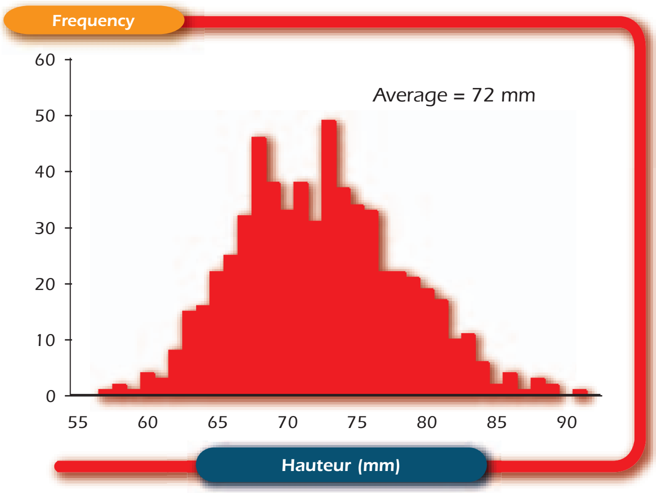

Figure 3.10 Hauteur Histogram

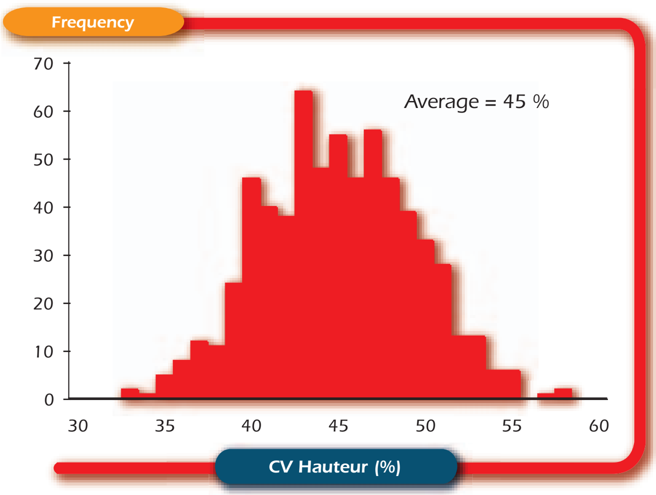

Figure 3.11 TEAM-3 CVH Histogram

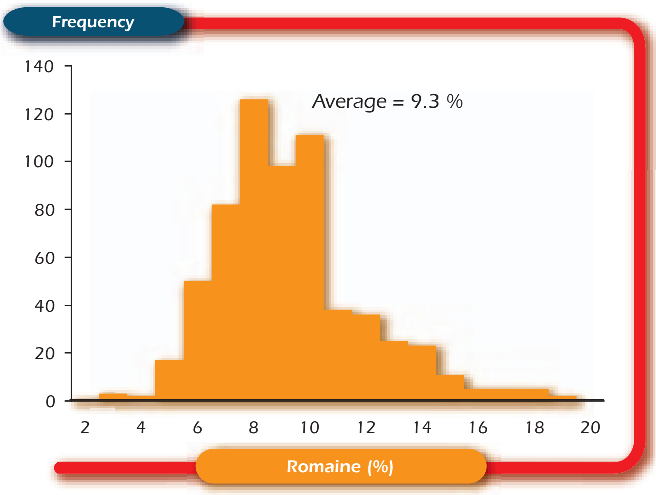

Figure 3.12 TEAM-3 Romaine Histogram

There are some interesting differences between the ranges of the TEAM-2 and TEAM-3 databases. The TEAM formulae are based on multiple regression statistical techniques and, in order to increase the general applicability of predictions, it is important to have as wide a range of inputs (raw wool measurements) as possible. In the development of the TEAM-2 prediction formulae, considerable effort was made to increase the ranges of raw wool properties between the processing consignments to improve the robustness of the formula.

In the original TEAM trials, combing batches were submitted for inclusion in the TEAM project and farm lots that did not have pre-sale staple measurements were sampled and tested post-sale. In effect, this meant that some key raw wool measurements were unknown at the time of blend construction and therefore restrictions could not be placed on inclusion or exclusion of lots from the blend on the basis of the raw wool attributes. As such, it was always likely that the ranges of the raw wool attributes from the TEAM-3 database would be smaller than TEAM-2.

In addition, the understanding of acceptable ranges and specification limits for staple measurements was not as clear in the 1980's as it is today, given the benefit of experience gained with raw wool measurements and prediction over the past 20 years. These trade experiences have resulted in application of greasy wool specifications for blend engineering, based on measurement. Today, for example, typical specifications require mean and range component values for Diameter and Staple Length, mean and minimum component values for Staple Strength and mean and maximum component values for Vegetable Matter. These, along with a TEAM-2 predicted Hauteur, form a common base for raw wool specification. With this in mind, restrictions in the ranges of raw wool attributes observed in the TEAM-3 data set are only to be expected. The inclusion of combing batches into the TEAM-3 program was on the basis of current commercial practice.

Specific comments on the raw wool characteristics depicted in Table 3.3 and Figures 3.1 to 3.9 are as follows:

Diameter: The upper limit in Fibre Diameter is lower in the TEAM-3 database, which is likely to be a reflection of the overall reduction in these types of wool being available, due to the reduction in the average Fibre Diameter of the Australian wool clip over the past 10 to 15 years.

Staple Length: Whilst the mean value is similar in both data sets, the maximum and minimum values have contracted in the TEAM-3 data set. The reduction in the maximum value is partly due to the lower range of diameter and also due to specification restrictions. The slightly higher minimum value may be due to industry experience that suggests shorter wools do not predict as well with the TEAM-2 formulae because they are close to the extremes of the data set used to generate the formulae. Some combers use specific mill based formulae for short wool blends.

Staple Strength: Under the appraisal system used during the TEAM-2 project it was difficult for subjective appraisal to differentiate the actual Staple Strength when it was greater than approximately 30 N/Ktex. Experience, and the use of prediction with TEAM-2, has resulted in topmakers having a better understanding of the available trade-offs between raw wool attributes as well as the cost of high or low strength wool.

Vegetable Matter: During the TEAM-2 project special effort was made to increase the range of Vegetable Matter blends in order to improve the robustness of the prediction formulae. Commercial decisions being made today clearly indicate that restrictions are placed on maximum Vegetable Matter levels. This has resulted in a lower range in Vegetable Matter for the TEAM-3 database. The influence of Vegetable Matter in the TEAM-3 prediction of Hauteur is further discussed in Section 6 of this report.

Other Measurements: The TEAM-3 trials have been designed to determine if improvements to the prediction formulae currently in use (TEAM-2) can be achieved with the addition of measurements that have been introduced since the TEAM-2 formulae were developed.

4. PROCESSING PERFORMANCE AND COMPARISON BETWEEN TEAM-2 AND TEAM-3

4.1 Hauteur, CVH and Romaine

Before examining the potential for new processing prediction formulae, it is worth considering the relationship between the actual processing performance of those consignments submitted and the performance predicted by the TEAM-2 formulae for each of Hauteur, Coefficient of Variation of Hauteur (CVH) and Romaine.

The average differences between actual and predicted (TEAM-2) Hauteur, CVH and Romaine are shown in Table 4.1 and graphically in Figures 4.1 to 4.3.

TABLE 4.1

COMPARISON BETWEEN ACTUAL AND TEAM-2 PREDICTED HAUTEUR, CVH AND ROMAINE

	Hauteur (mm)			CVH (%)			Romaine (%)		
	Actual	Predicted*	Diff.	Actual	Predicted*	Diff.	Actual	Predicted*	Diff.
Mean:	72.0	66.9	+ 5.1	44.9	47.4	- 2.5	9.3	7.1	+ 2.2
St Dev:	5.8	5.2	3.7#	4.4	3.0	3.2#	2.6	1.5	1.8#

* Predicted using TEAM-2 General Formulae (1988)

\# These values are the standard deviations of the differences between actual and predicted Hauteur, CVH and Romaine.

Using the consignments submitted in this trial, the average difference between actual Hauteur and TEAM-2 predicted Hauteur is +5.1mm. Figure 4.1 shows that the differences are larger for those consignments with Hauteur values in excess of 75mm. Approximately 31% of the consignments submitted for TEAM-3 have Hauteur values of 75mm or greater and the average difference between actual and predicted Hauteur for these consignments is 7.3mm.

The average difference between actual CVH and TEAM-2 predicted CVH is -2.5%. Figure 4.2 shows that for the majority of consignments, the actual CVH is lower than that predicted by the TEAM-2 formulae. Only 20% of the consignments received for TEAM-3 have a higher actual CVH than predicted.

The average difference between actual Romaine and TEAM-2 predicted Romaine is +2.2%. These differences are shown graphically in Figure 4.3. Only 8% of the consignments received for TEAM-3 have a lower Romaine than that predicted by the TEAM-2 formulae.

Since the TEAM-2 formulae were derived, processing mills have been encouraged to produce tops with lower CVH values. This has involved removing more short fibre during combing, which has the effect of reducing CVH, increasing Hauteur and increasing Romaine.

On each of Figures 4.1 to 4.3, the trendline from the 1988 TEAM-2 database has been added to the graph as a comparison. These trend lines suggest that although processing performance has changed since 1988, the slopes of the relationship between actual and predicted Hauteur, CVH and Romaine are very similar. The observation that longer tops are performing better in comparison to the Hauteur prediction formula is consistent with what was observed in the original TEAM-2 trial.

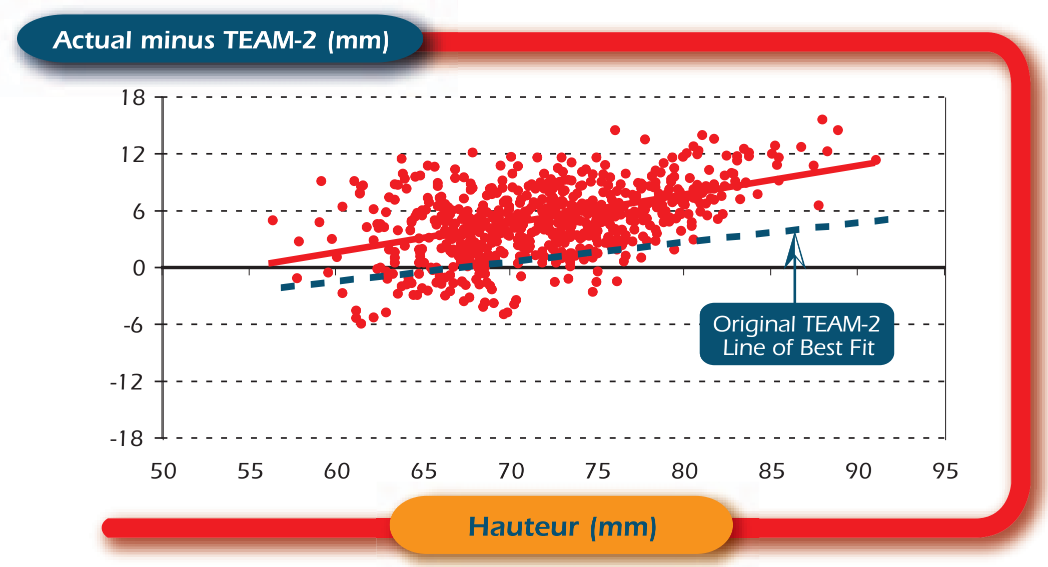

Figure 4.1 Hauteur Differences (Actual minus TEAM-2)

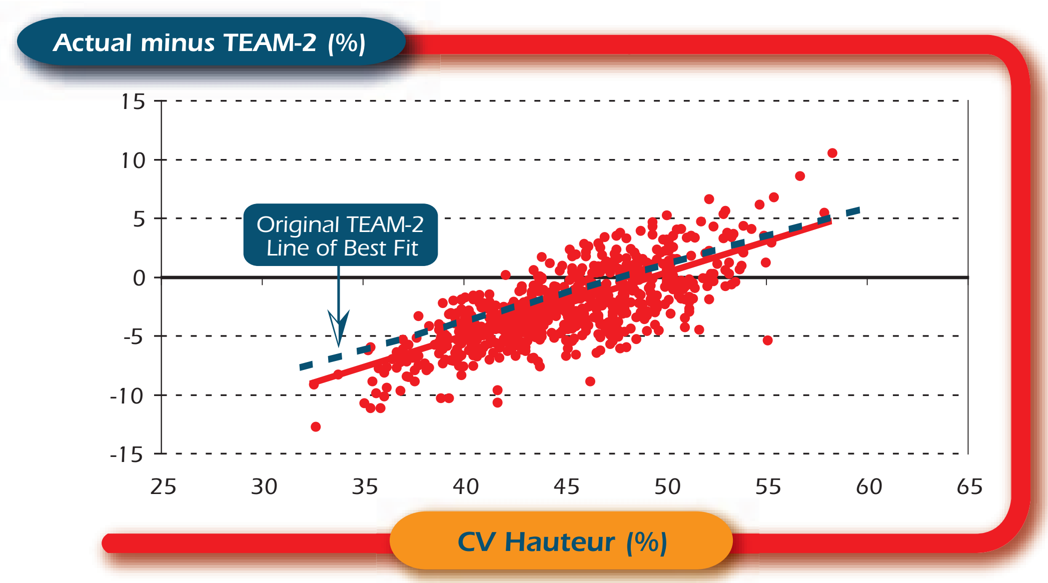

Figure 4.2 CVH Differences (Actual minus TEAM-2)

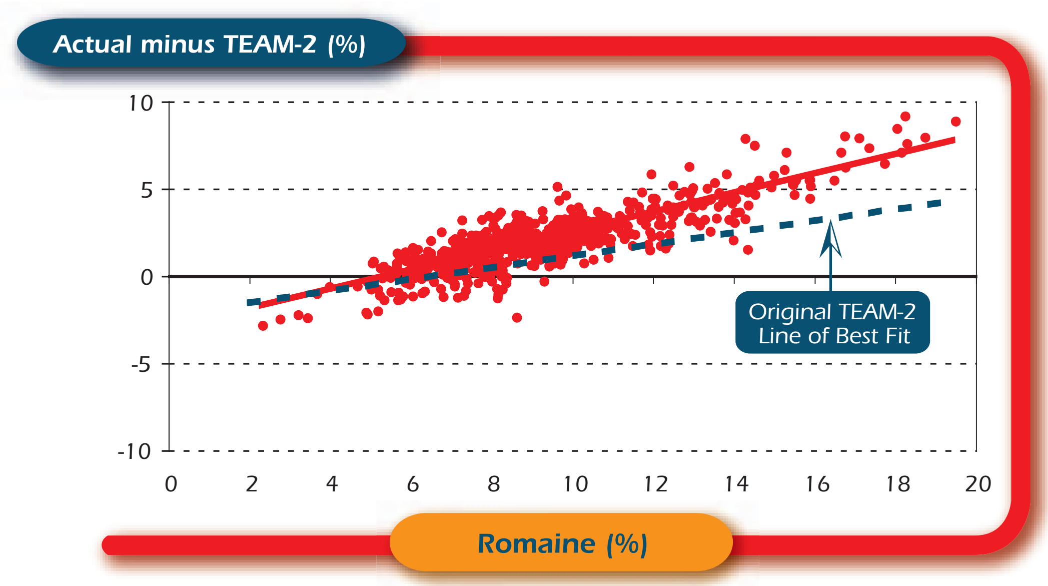

Figure 4.3 Romaine Differences (Actual minus TEAM-2)

4.2 Comparison of Mill Performance on a Regional Basis

Section 4.1 has shown that, on average, mills produce tops with Hauteur values 5.1mm longer than predicted by the TEAM-2 General Formulae. However, it is also interesting to examine the differences between actual and predicted Hauteur at a regional level.

Whilst maintaining the confidentiality of individual mills, the data collected allows a comparison of processing performance on a regional basis. Table 4.2 and Figures 4.4 to 4.6 compare Actual Hauteur, Predicted Hauteur, CVH and Romaine for the 5 participating regions. The predicted values are derived from the TEAM-2 General Formulae.

Without exception, each of the 5 regions examined are producing tops that have a longer Hauteur, a lower CVH and a higher Romaine than predicted by the TEAM-2 General Formulae. Examination of Figures 4.4 to 4.6 indicate a very similar pattern regardless of processing region.

TABLE 4.2

COMPARISON BETWEEN ACTUAL AND PREDICTED HAUTEUR, CVH AND ROMAINE FOR DIFFERENT REGIONS PARTICIPATING IN TEAM-3

	Number of			Actual – Predicted		
Region	**Mills**	**Consignments**		**Hauteur (mm)**	**CVH (%)**	**Romaine (%)**
Australia	7	97	Mean	6.1	-3.0	3.1
			St. Dev (Diff.)	2.5	2.6	2.1
China	11	205	Mean	5.5	-2.8	2.0
			St. Dev (Diff.)	3.6	2.5	1.7
India	5	130	Mean	4.7	-2.4	1.6
			St. Dev (Diff.)	4.0	3.6	1.5
Europe	7	99	Mean	6.6	-3.9	2.3
			St. Dev (Diff.)	3.7	2.9	1.3
Other Asia	4	116	Mean	3.1	-0.4	2.0
			St. Dev (Diff.)	3.5	3.5	1.7

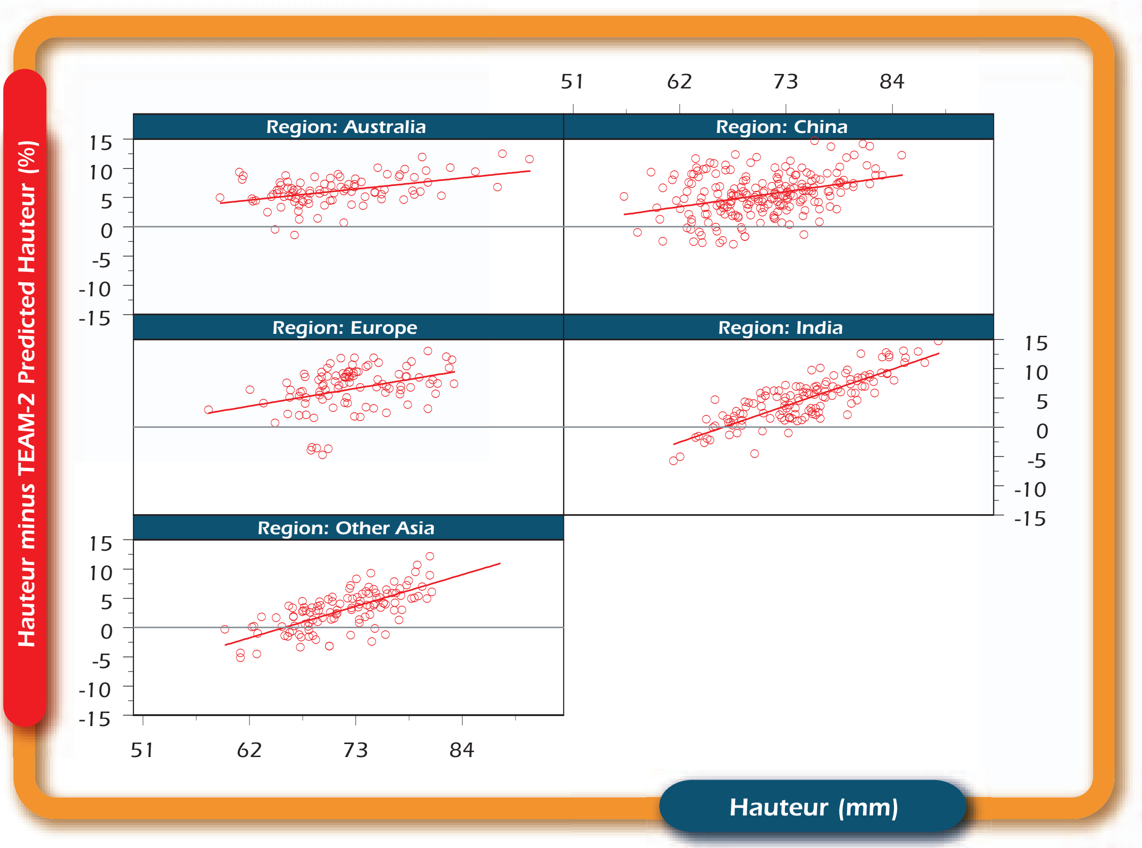

Figure 4.4 TEAM-2 Residual Hauteur against Actual Hauteur: Regional Comparison

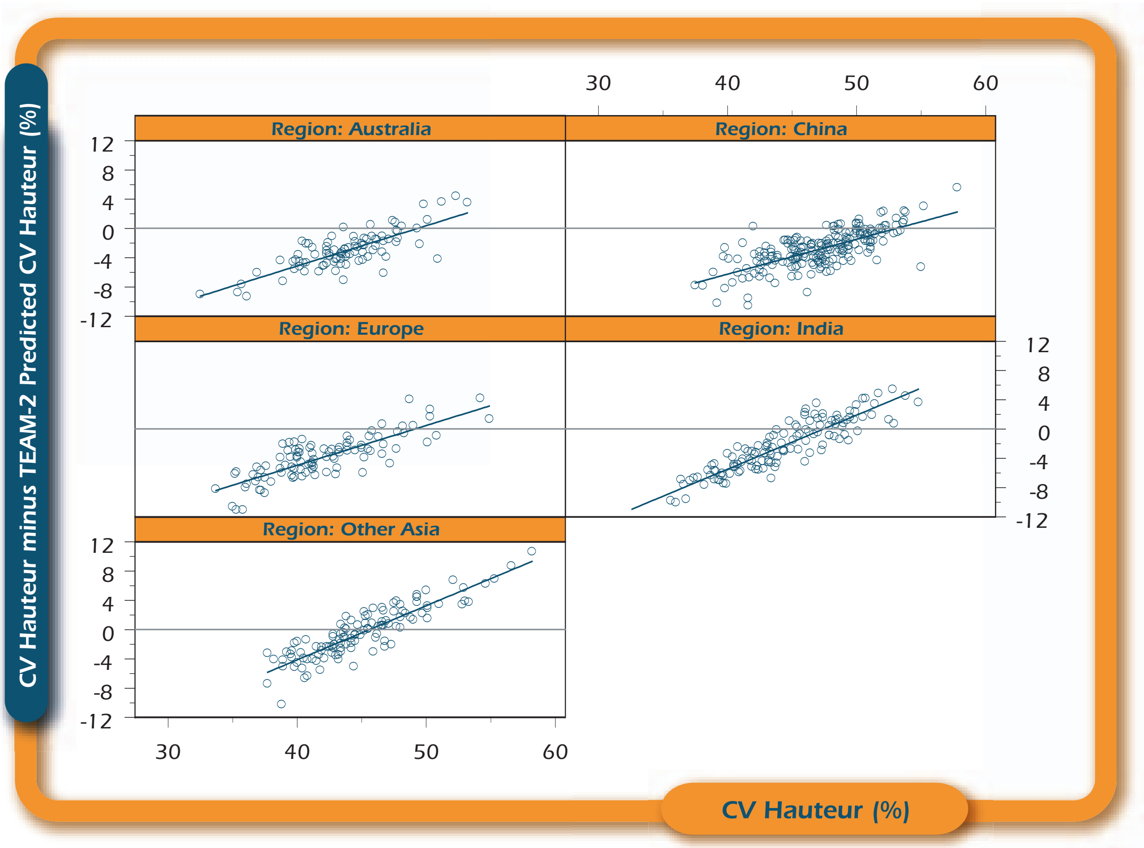

Figure 4.5 TEAM-2 Residual CVH against Actual CVH: Regional Comparison

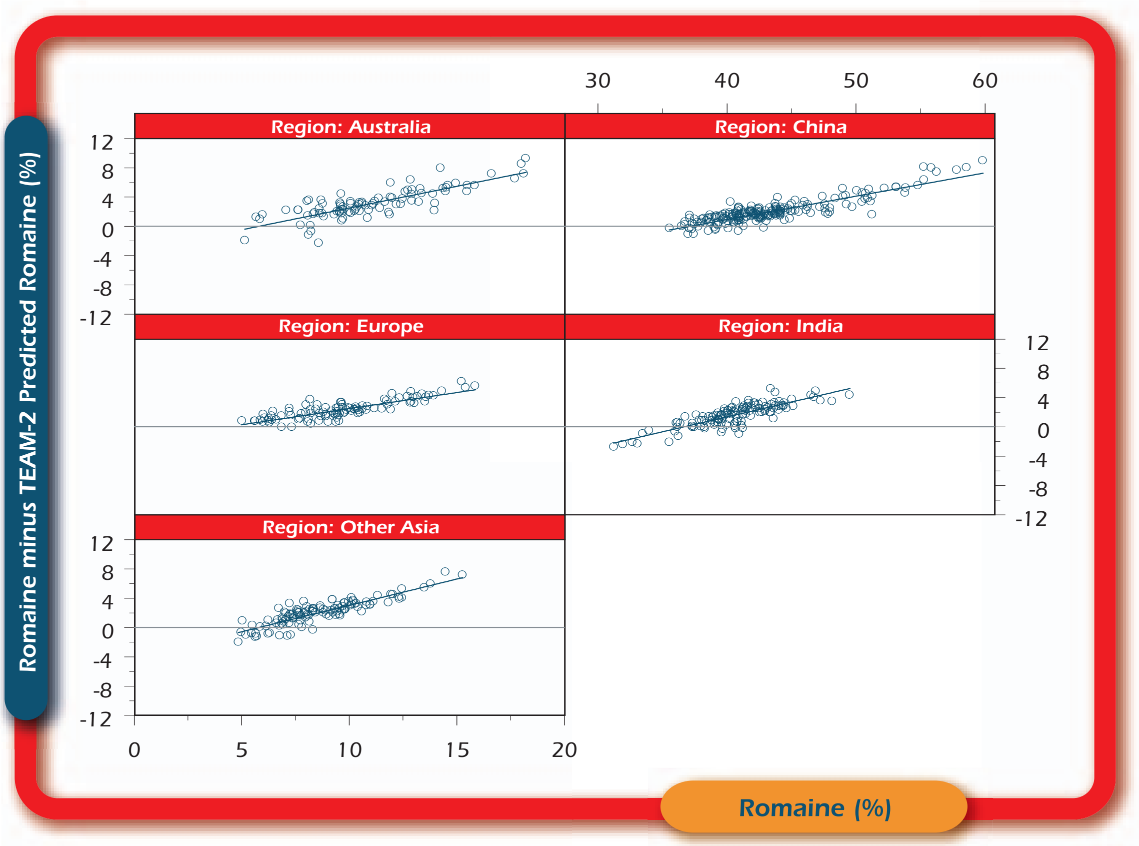

Figure 4.6 TEAM-2 Residual Romaine against Actual Romaine: Regional Comparison

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5. CORE/COMB RELATIONSHIPS

5.1 Mean Fibre Diameter and Coefficient of Variation of Diameter

For each processing consignment submitted as part of the TEAM-3 trial, a minimum of five samples of top was provided to AWTA Ltd for analysis. Figure 5.1 shows the relationship between the greasy wool Mean Fibre Diameter (Core) and the top Mean Fibre Diameter (Comb) for the TEAM-3 database. The diameter of the top measured by AWTA Ltd using Laserscan, was used in this analysis. On average, the Mean Fibre Diameter of the top was 0.20μm coarser than the Mean Fibre Diameter of the greasy wool.

Figure 5.2 compares the Coefficient of Variation of Diameter (CVD) of the greasy wool and the top. It shows that the average CVD was 0.9% lower in the top than it was in the greasy wool. This is an expected result because processing is understood to remove proportionally more fine fibres than coarse fibres as noil. This has the effect of increasing the Fibre Diameter in the top (Figure 5.1) and decreasing the Fibre Diameter variation in the top (Figure 5.2).

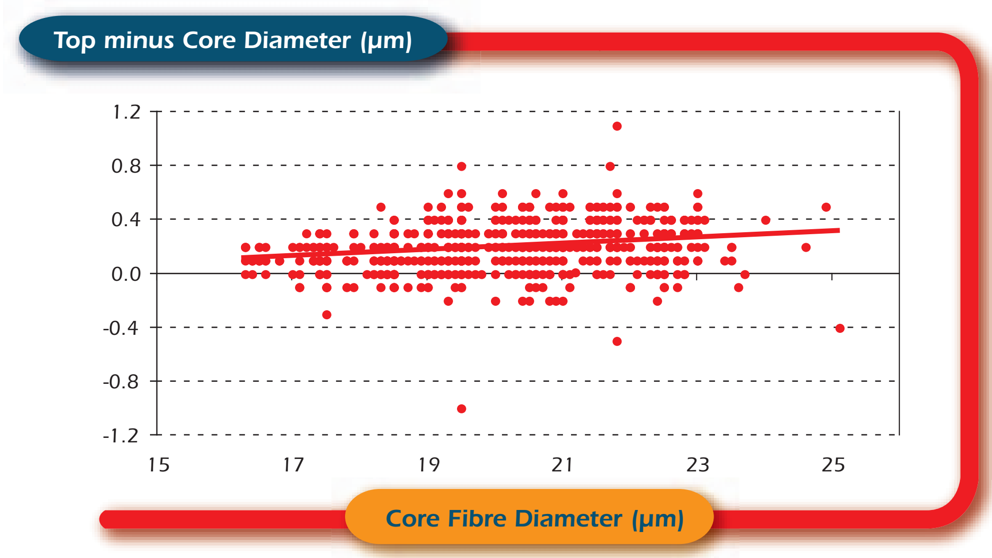

Figure 5.1 Core/Comb Fibre Diameter Comparison

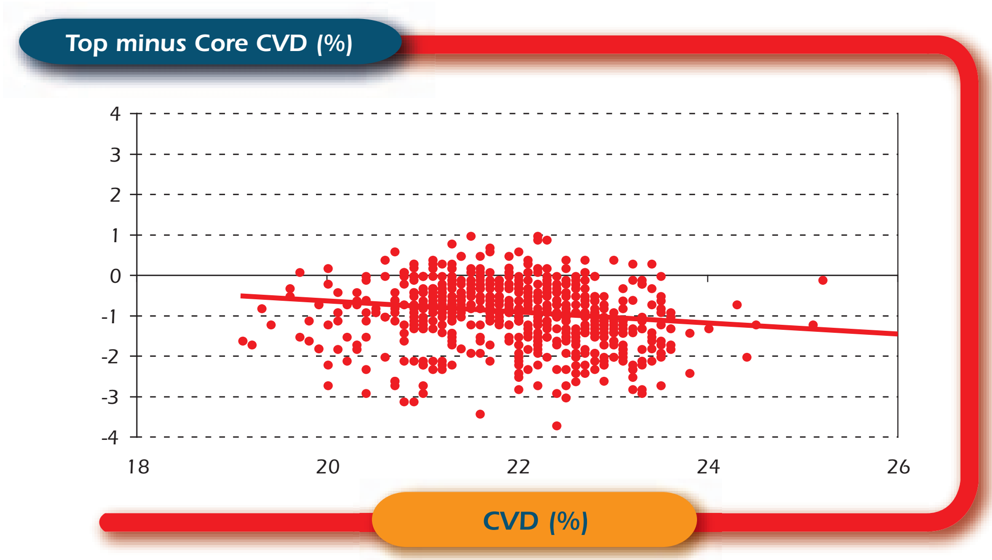

Figure 5.2 Core/Comb CVD Comparison

5.2 Processing Yield

A comparison between the actual Top & Noil Yield achieved by the processing mills and the predicted yield using the Schlumberger Dry Top & Noil Yield (SDRY) formula is shown in Figure 5.3. The actual processing yield of the TEAM-3 consignments was, on average, 1.1% higher than the yield predicted by the SDRY formula.

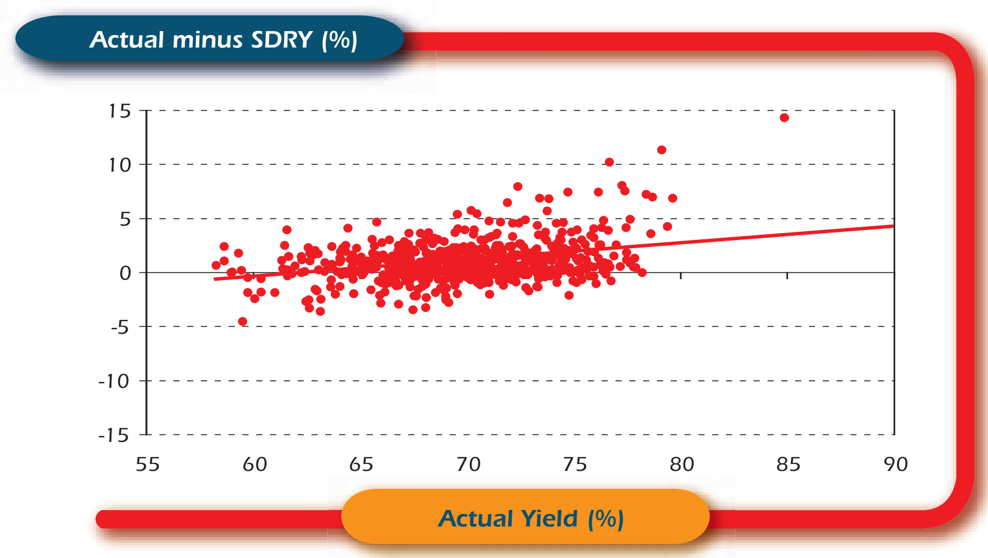

Figure 5.3 Comparison between Actual and Predicted Schlumberger Dry Top & Noil Yield

6. TEAM-3 DATABASE - PREDICTION OF HAUTEUR

Section 4 of this report compared the processing performance of consignments submitted as part of the TEAM-3 trial against the TEAM-2 benchmark. However, one of the original aims of the TEAM-3 project was to examine the possibility of creating new processing prediction formulae based on current commercial processing performance.

The authors of the TEAM-2 report (1988) recognised that a feature of the formulae was their simplicity. A minimum number of raw wool factors with purely additive effects enabled the creation of General Formulae that could be used across various wool types and mills. The formulae used to predict Hauteur were developed using multiple regression techniques. Other more sophisticated approaches were considered by the TEAM-2 committee but these provided no improvement over the simpler approach. The TEAM-3 Steering Committee decided that a similar approach would be taken for the analysis of the TEAM-3 database.

The data from the consignments submitted for the TEAM-3 trial was analysed using the S-Plus (2002) statistical package. The analysis included re-determining the coefficients for the TEAM-2 formula for Hauteur, CVH and Romaine and then adding new variables to the model. The variables added were Mean Fibre Curvature (MFC), Coefficient of Variation of Diameter (CVD) and Coefficient of Variation of Length (CVL). Multiple regression analyses were conducted, which plotted Hauteur, CVH and Romaine against these raw wool factors.

As explained in the TEAM-2 report (1988), the strength of a regression relationship may be measured by two statistics:

- The coefficient of multiple determination (R^2) indicates the fraction of the variation in Hauteur between the consignments which is explained by the raw wool data used in the formula. It reflects the level of association between the raw wool variables and Hauteur, and is often called the degree of association. The R^2 is expressed as a percentage.

- The standard error (SE) of the differences between actual and predicted Hauteur is a measure of the reliability of the raw wool data as a predictor of Hauteur. The lower the SE the more reliable the formula. The SE is expressed in the units of measurement of the variable being considered (i.e. as mm for Hauteur and as a percentage for CVH and Romaine).

For reference, the TEAM-2 General Formulae for Hauteur (H), CV Hauteur (CVH), and Romaine (R), as published in 1988, are as follows:

Hauteur = 0.52L + 0.47S + 0.95D – 0.19M* – 0.45V – 3.5 + [MA1]

CV Hauteur = 0.12L – 0.41S – 0.35D + 0.20M* + 49.3 + [MA2]

Romaine = -0.11L – 0.14S – 0.35D + 0.94V + 27.7 + [MA3]

Where:

Where:	L	=	Staple Length (mm)
	S	=	Staple Strength (N/ktex)
	D	=	Mean Fibre Diameter (μm)
	V	=	Vegetable Matter Base (%)
	M*	=	Adjusted Mid-Breaks
	MA	=	Mill Adjustment Factor (MA1 = Hauteur, MA2 = CVH, MA3 = Romaine)

Table 6.1 presents the results of the regression analysis for the Hauteur prediction based on the TEAM-3 database. Regression 1 in this table is an analysis of the TEAM-3 database using Staple Length (SL), Staple Strength (SS), Fibre Diameter (D), Adjusted Mid-Breaks (M*) and Vegetable Matter Base (V) as a function of Hauteur. These are the same parameters that formed the basis of the TEAM-2 formula. It is noticeable that the regression analysis on the TEAM-3 database gives a lower Standard Error (SE) than was reported for TEAM-2, possibly suggesting improved reliability of prediction. The coefficients for SS, SL, D and M* for Regression 1 are similar to the TEAM-2 coefficients.

The effect of Vegetable Matter Base (VM) however is different between TEAM-2 and TEAM-3. It is expected that as the level of VM in a consignment increases, the Hauteur will decrease. This was the case in TEAM-2 where VM had a negative effect on Hauteur (–0.45). However the TEAM-3 analysis shows that VM has a positive but insignificant influence on Hauteur (+0.03). This is most likely due to the very small range of VM in the TEAM-3 database. The average VM of the database was 1.2% with a range from 0.3% to 5.3%. However, of the 647 consignments, 91% have a VM result of 2.0% or less. The narrow range of VM can be seen clearly in Figure 6.1. With such a narrow range, it would be expected that VM would have a minimal effect on Hauteur. This may not be true if consignments of high VM are processed into top. In addition to the relatively low range of VM, mill management decisions may also contribute to the insignificant influence of VM on Hauteur. This comment was also made by the authors of the TEAM-2 report (1988).

One of the reasons for conducting the TEAM-3 Processing Trial was to examine the impact of additional measurements, such as Coefficient of Variation of Diameter (CVD) and Mean Fibre Curvature (MFC), on the prediction of processing performance. Regressions 2 to 8 in Table 6.1 show the results when various combinations of CVD, MFC and Coefficient of Variation of Length (CVL) are added to the TEAM-3 variables.

TABLE 6.1

STATISTICAL ANALYSIS USING ADDITIONAL FACTORS OF CVD, MFC AND CVL TO PREDICT HAUTEUR

REGRESSION	SL	SS	D	M*	VM	CVD	MFC	CVL	SE(mm)	R^2
TEAM-2	0.52	0.47	0.95	-0.19	-0.45				3.4	84%
1 TEAM-3	0.58	0.45	1.00	-0.17	(0.03)				2.58	82%
2 TEAM-3 +CVD	0.47	0.33	1.37	-0.19	(-0.12)	-0.90			2.53	83%
3 TEAM-3 + CVL	0.46	0.41	1.24	-0.17	(0.22)			-0.40	2.51	83%
4 TEAM-3 + MFC	0.58	0.45	1.16	-0.17	(0.05)		(-0.04)		2.58	82%
5 TEAM-3 + CVL + CVD	0.41	0.33	1.45	-0.18	(0.08)	-0.63		-0.32	2.49	83%
6 TEAM-3 + CVD + MFC	0.47	0.33	1.41	-0.19	(-0.12)	-0.89	(0.01)		2.53	83%
7 TEAM-3 + CVL + MFC	0.46	0.41	1.31	-0.17	(0.23)		(0.02)	-0.40	2.51	83%
8 TEAM-3 + CVD + CVL + MFC	0.41	0.33	1.45	-0.18	(0.08)	-0.63	(0.00)	-0.32	2.49	83%

Note: All coefficients that were not statistically significant are bracketed.

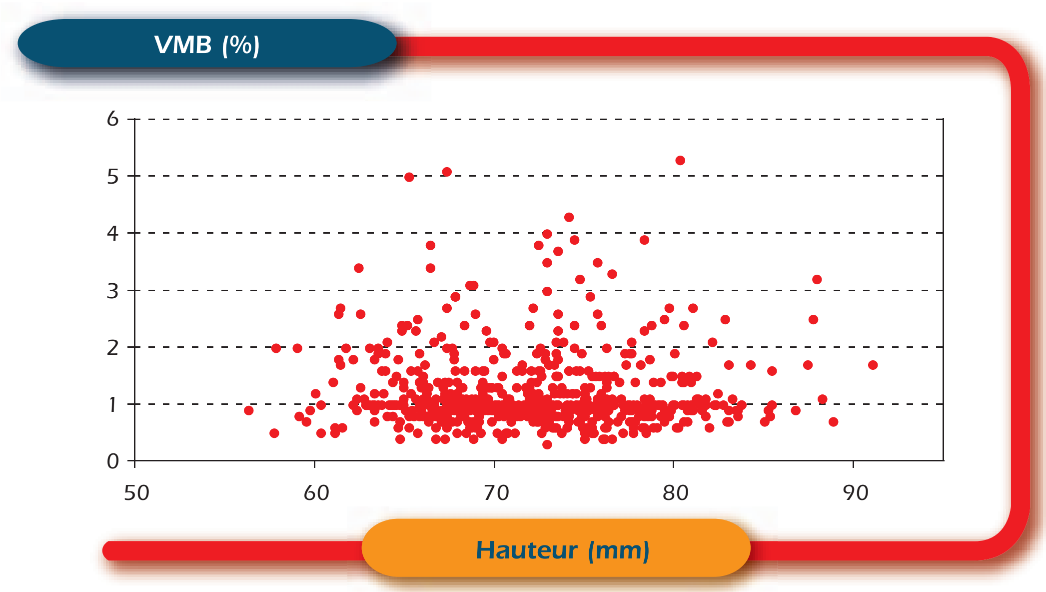

Figure 6.1 Relationship between Vegetable Matter and Hauteur

6.1 The Addition of CVD and CVL to the TEAM Model

Regressions 2, 3 and 5 in Table 6.1 show the impact when CVD and CVL are added to the basic TEAM regression model. The addition of CVD (Regression 2) and CVL (Regression 3) provides a small reduction in the SE over Regression 1. The coefficients for CVD and CVL are both statistically significant indicating that they can influence processing performance. The combination of CVL and CVD with the TEAM variables (Regression 5) provides another small reduction in the SE. However, the addition of these parameters does not produce a significant reduction in the SE of the prediction model.

It is worth noting that when CVD is added to the model together with the TEAM-3 variables (Regression 2) that the coefficients for both SS and CVD are significant. It has been previously suggested (Lamb, 2000) that CVD could replace SS as a predictor of processing performance. This analysis suggests that SS is still important for the processing prediction of consignments and cannot be replaced by CVD alone.

The addition of CVL to the TEAM-2 Hauteur formula was considered by the TEAM committee in 1988. Early analysis of the database indicated that CVL did have a small influence on processing performance. However, analysis of the total database at the conclusion of the TEAM-2 trial did not confirm the significance of CVL in any prediction formulae. It was suggested at the time that CVL may be significant for a mill-specific formula. As such, it is not surprising that CVL could be considered as an addition to the processing prediction formulae following the TEAM-3 analysis.

Based on the regression analysis of the TEAM-3 database to this point, Regression 5 from Table 6.1 is considered the most appropriate equation for further evaluation.

6.2 The Addition of MFC to the TEAM Model

A number of research papers (Haigh, 2002; Peterson, 2002; Vizard and Hansford, 1999; Stevens and Mahar, 1995; Stevens and Crowe, 1994; Kurdo *et al*, 1984; Marler, 1985; Hunter and Gee, 1980; Turpie and Shiloh, 1973; and, Cilliers and Robinson, 1968) have suggested that wool exhibiting properties of low MFC, low crimp frequency or low Resistance to Compression shows a processing benefit in terms of longer Hauteur and lower Romaine. These potential processing advantages have been identified by comparing the extremes of MFC in selected individual fleeces. TEAM-3 relates to the processing results for consignments rather than sale lots or fleeces, hence the range in MFC is likely to be less than reported in these research trials. The range in MFC for each micron level in TEAM-3 is approximately 10 to 15 degrees/mm (Figure 6.2).

All reports to date on the TEAM-3 trial (Lindsay *et al*, 2002a; Lindsay *et al*, 2002b; TEAM-3 Steering Committee, 2003; and, Lindsay *et al*, 2003) have been unable to demonstrate any processing advantage of low MFC when examining commercial consignments. The final analysis of the TEAM-3 database has shown that the inclusion of MFC does not improve the processing prediction model (Regression 4 in Table 6.1).

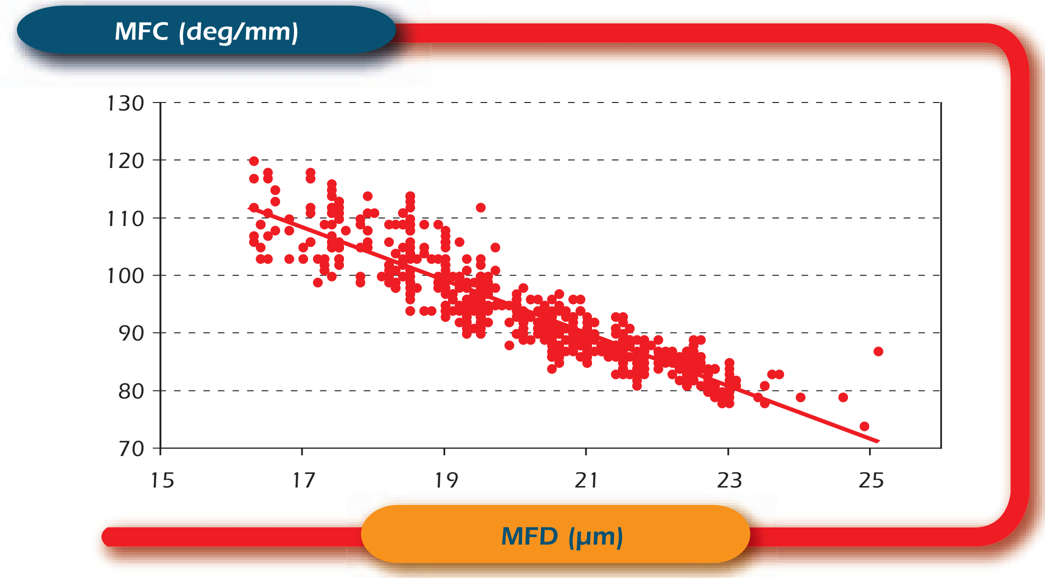

Figure 6.2 Fibre Diameter and Fibre Curvature Relationships

Figure 6.3 is a plot of Mean Fibre Curvature against the TEAM-3 Residual Hauteur (i.e. Actual Hauteur minus TEAM3 Predicted Hauteur, where Regression 5 in Table 6.1 is used to calculate the predicted values). If the inclusion of MFC in any processing prediction model resulted in an improvement in processing prediction, then it would be expected that Figure 6.3 would exhibit a significant slope effect. However it is clear from this plot that MFC does not influence processing prediction based on the commercial consignments processed as part of the TEAM-3 trial.

In addition, the trend line on Figure 6.3 shows that as MFC decreases, the difference between Actual and Predicted Hauteur also decreases. Based on the MFC research studies this is not the expected result. If consignments of low MFC did exhibit a processing advantage then the differences between Actual and Predicted Hauteur would increase with decreasing MFC.

Figure 6.3 has been dissected further to compare the relationships for consignments of similar Fibre Diameter. The MFC relationship of all consignments with a diameter of 16.0µm to 18.0µm was examined. This was repeated for wool of diameter 18.1µm to 20.0µm, and 20.1µm and greater. The plots of these comparisons appear in Appendix 2. Once again, no relationships are evident in these analyses.

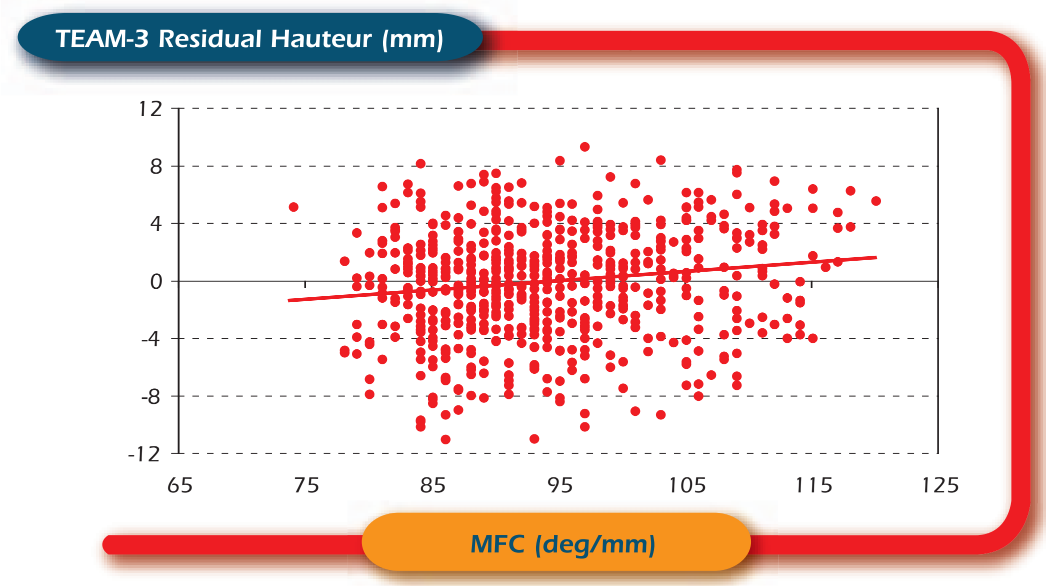

Figure 6.3 Relationship between MFC and TEAM-3 Residual Hauteur for the TEAM-3 Database

6.3 Review of the Impact of Vegetable Matter Base on the TEAM Prediction of Hauteur

As shown in Table 6.1 and in earlier discussions, the analysis of the TEAM-3 database has indicated that the coefficient for Vegetable Matter Base (VM) was both positive and not significant, from a statistical point of view. This would imply that VM has no impact on the prediction of Hauteur. However, general experience in topmaking would suggest that, all other things being equal, consignments containing high levels of VM will have a lower Hauteur than consignments containing low levels of VM. At the IWTO Meeting in Evian, May 2004, the TEAM-3 Committee Chairman offered to review this apparent anomaly in the TEAM-3 analysis.

One of the basic underlying assumptions for multiple regression statistics is that there is sufficient variation in each of the input variables, for example VM, to influence the variation in the output result, in this case Hauteur. As mentioned earlier, the range of VM in the TEAM-2 database was much wider (0.1% to 10.2%) than in the TEAM-3 database (0.3% to 5.3%). It is possible that the limited VM range in the TEAM-3 database is the reason behind the anomaly.

Following the IWTO Meeting in Evian, the impact of the range in VM on the prediction of Hauteur was further examined by re-analysing the TEAM-2 database using restrictions on the range in VM to more closely match the range of VM in the TEAM-3 database. All consignments from the TEAM-2 database which had a VM greater than 3% were removed and a statistical analysis was performed on the remaining 371 consignments. This analysis was repeated on 283 TEAM-2 consignments following removal of all consignments with a VM greater than 2%.

The results are presented in Table 6.2.

TABLE 6.2

ANALYSIS OF THE TEAM-2 DATABASE FOLLOWING REMOVAL OF CONSIGNMENTS WITH VM GREATER THAN 3% (REGRESSION 1) AND GREATER THAN 2% (REGRESSION 2)

Regression		No.	SL	SS	D	M*	VM	SE (mm)	R^2
	TEAM-2 (All Data)	464	0.52	0.47	0.94	-0.19	-0.45	3.41	84%
1	TEAM-2 (VM ≤ 3%)	371	0.54	0.49	0.88	-0.18	(-0.09)	3.48	83%
2	TEAM-2 (VM ≤ 2%)	283	0.50	0.46	0.89	-0.19	(+0.79)	3.42	83%

Note: All coefficients that were not statistically significant are bracketed. They relate to the VM coefficients where the range of VM in the analysed data was reduced.

Table 6.2 shows that the reduced range in VM causes the coefficient for VM to become statistically non-significant and the coefficient also becomes positive in Regression 2 as the range in VM is reduced further. Using either Regression 1 or 2 in Table 6.2 to predict the Hauteur of consignments with high VM (greater than 4%) produced poorer results (average difference = 2.5mm) than when high VM consignments were included in the development of the prediction model (average difference = 0.6mm.

A similar situation would, for example, exist in respect to Fibre Diameter if a combing mill was only processing 22.0µm to 22.5µm batches and the mill had developed its own specific Hauteur prediction formula. In such a case, it is most likely that diameter would not be included in the mill specific formula and erroneous results could be produced if the mill changed the diameter of the consignments it processed. For this reason it has always been recommended that the development of any mill specific formula should start with the TEAM General Formula (see Appendix 3).

This analysis provides three options to account for the influence of VM on the prediction of Hauteur:

1. Despite the statistical non-significance, include the coefficient for VM (+0.03) determined from the analysis of the TEAM-3 database;

2. In acknowledgement of the statistical non-significance and positive value, exclude the VM term from the model; or

3. As the TEAM-2 database had a much wider range in VM than the TEAM-3 database, use the TEAM-2 coefficient for VM (–0.45) in the TEAM-3 prediction model.

The last option is technically feasible as any coefficient is simply an indication of the sensitivity of Hauteur to a change in that particular characteristic. Table 6.3 provides a comparison of the three alternatives. Regression 1 in Table 6.3 is the same equation as Regression 5 from Table 6.1 which was deemed to be the most appropriate model for further evaluation.

TABLE 6.3

STATISTICAL ANALYSIS FOR DIFFERENT APPROACHES TO VM IN THE REGRESSION MODELLING

Regression	SL	SS	D	M*	VM	CVD	CVL	SE (mm)	R^2
1 TEAM-3 + CVD + CVL	0.41	0.33	1.45	-0.18	(0.08)	-0.63	-0.32	2.49	83%
2 TEAM-3 + CVD + CVL (No VM)	0.41	0.33	1.47	-0.18		-0.65	-0.32	2.49	83%
3 TEAM-3 + CVD + CVL – 0.45VM	0.42	0.34	1.37	-0.18	-0.45#	-0.55	-0.35	2.50	83%

Note: All coefficients that were not statistically significant are bracketed.
The # indicates that this coefficient was derived from the TEAM-2 analysis and included here due to the lack of range in VM in the TEAM-3 database.

On the basis of the SE and R^2 values, there is no difference between the three alternatives. In addition there are only small differences in the coefficients for the other raw wool characteristics. Therefore, Equation 3 from Table 6.3 is the preferred option as it is better able to reflect the sensitivity of Hauteur to the widest range of VM in the consignments, including consignments with high levels of VM.

It should also be recognised that although VM was not a significant variable for the prediction of Hauteur based on the analysis of the TEAM-3 database, its impact was found to be significant in the prediction of Romaine (see Section 8).

6.4 The Use of M* in the TEAM Model

Since the TEAM-2 report was published in 1988, there has been some conjecture over the use of M* (adjusted Mid-Breaks) in the TEAM-2 general formula. M* is the adjusted percentage of Mid-Breaks (M) and all M values of up to 45% are replaced by a value of 45% for M* in the TEAM-2 formula. For values of M greater than 45%, the measured value itself is used as M* in the formula. The TEAM-2 Committee included M* rather than M in their formula because it was evident on scatter plots that there was no obvious trend between the Hauteur residuals and Mid-Breaks for values of M to 45%. However for Mid-Break values in excess of 45% a trend was evident.

The use of M rather than M* would simplify the TEAM formulae. In addition, due to the use of M* in the TEAM-2 formulae, it is not possible to easily calculate an average Hauteur or CVH when using simple weighted averages for the combination of a number of Sale Lots. A new formula with M rather than M* would allow buyers to easily combine the Hauteur values of individual Sale Lots.

Using Regression 3 from Table 6.3 as the benchmark, the TEAM-3 database was analysed to compare the use of M* with the use of the actual mid break percentage (M). Table 6.4 shows that the use of M is equivalent to M* in the prediction model. Consequently, the use of M could be considered as a possible replacement for M*.

TABLE 6.4

STATISTICAL ANALYSIS USING M INSTEAD OF M*

Regression	SL	SS	D	M*	M	VM	CVD	CVL	SE(mm)	R^2
1 TEAM-3 + CVD + CVL – 0.45VM	0.42	0.34	1.37	-0.18		-0.45#	-0.55	-0.35	2.50	83%
2 M* replaced by M	0.43	0.35	1.38		-0.15	-0.45#	-0.59	-0.32	2.49	83%

Note: The # indicates that this coefficient was derived from the TEAM-2 analysis and included here due to the lack of range in VM in the TEAM-3 database.

As the use of M would simplify the TEAM formula, **Regression 2 in Table 6.4 is the proposed TEAM-3 prediction formula for Hauteur.** It should be noted that this formula contains a constant term which includes an adjustment associated with individual mill differences. For the entire TEAM-3 database, the adjustment equals 21.8. Therefore, the proposed TEAM-3 formula for Hauteur is as follows:

$$\textbf{Hauteur} = 0.43L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 21.8$$

With the exception of the VM, the relative importance of the remaining variables in Table 6.4 has been estimated from the statistical significance of the regression terms. Table 6.5 provides an estimate for the relative importance of each variable with the most significant factor, Mean Fibre Diameter, given a rating of 100. The next most important variable after MFD is Staple Length (96) followed by Mid-Breaks (91). Table 6.5 provides a comparison to the TEAM-2 (1988) results where Staple Length had a rating of 100, followed by Staple Strength (88).

The fact that the importance of Staple Strength has decreased from TEAM-2 to TEAM-3 is likely to be a reflection of the fact that the TEAM-3 regression formula includes CVD, which has been suggested as a potential indicator of Staple Strength. It is important to note however that, based on this analysis, Staple Strength has a much greater influence on Hauteur than does CVD.

TABLE 6.5

THE RELATIVE IMPORTANCE OF RAW WOOL CHARACTERISTICS FOR THE PREDICTION OF HAUTEUR

Characteristic	Relative Importance TEAM-3	Relative Importance TEAM-2
Diameter	100	46
Staple Length	96	100
Mid-Breaks	91	NA
Adjusted Mid-Break	NA	40
Staple Strength	72	88
CV Length	40	NA
CV Diameter	28	NA
Vegetable Matter	–	19

Figure 6.4 compares the actual Hauteur values with the Residual Hauteur. The Residual Hauteur was calculated by subtracting the predicted Hauteur values from the actual Hauteur values. The predicted Hauteur was calculated using the proposed TEAM-3 formula listed above.

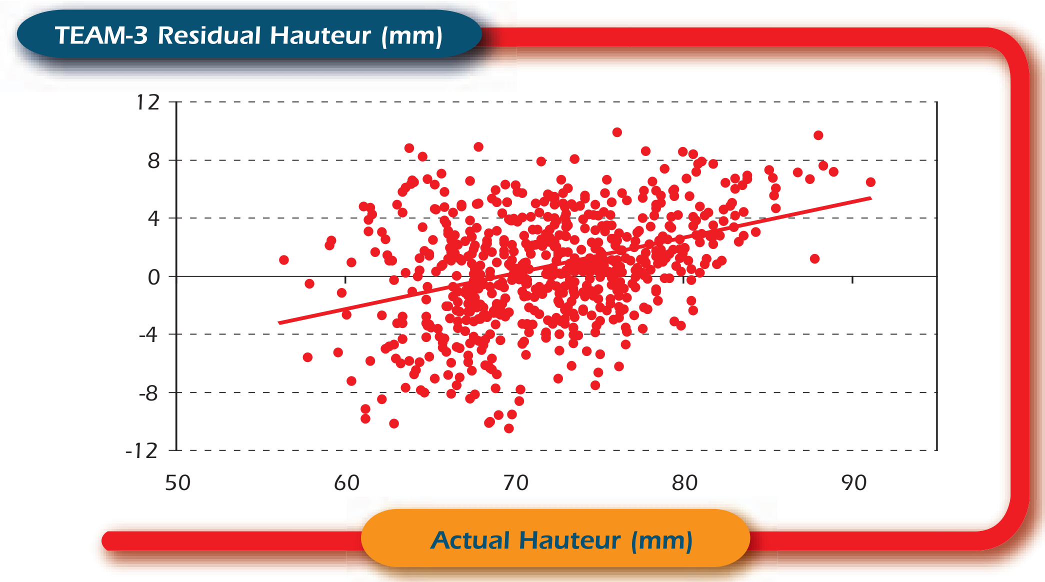

Figure 6.4 Relationship between Actual Hauteur and TEAM-3 Residual Hauteur

The existence of a slope on the TEAM-3 residuals in Figure 6.4 is indicative of some factor, that can have influence on the Hauteur, being absent from the formula. This same phenomenon was also evident in the TEAM-2 analysis. It is generally acknowledged that there will be a strong interaction between the Hauteur, the CVH and the Romaine of any top for any given consignment. Allen (1991) demonstrated the influence of CVH (over the 34% to 60% range) and the shape of the Hauteur diagram on the prediction of Hauteur. Market forces to produce a low CVH or less Romaine will clearly influence the Hauteur of the top produced.

One approach to investigate the impact of the above interactions is to examine the inclusion of both the actual CVH and the actual Romaine into the Hauteur prediction formula. Their inclusion is not to develop a formula per se, as they are clearly not known until the wool has been processed, but rather to quantify the impact that they are having on the data. In part they are a reflection of the machine settings, the processing conditions and other mill variables that are often difficult to quantify.

An analysis of the TEAM-3 residuals shown in Figure 6.4 indicated that most of the slope effect was related to the CVH of the top with Romaine having a marginal effect. The inclusion of the actual CVH into the regression reduced the SE from 2.5mm to 1.6mm and increased the R^2 from 83% to 93%. To improve the prediction of topmaking outcomes beyond the normal regression approach will require a clearer understanding and accounting of this interaction.

On the basis of the above analysis, the use of actual CVH, post processing, or the predicted CVH from a general TEAM formula, prior to processing, could provide valuable information to individual mills on how their processing performance differs or is likely to differ from the general formula for predicted Hauteur.

Further analysis of the residuals shows that approximately 75% of the consignments fall within a narrow range of ±4mm of the achieved Hauteur (Figure 6.5). This was similar to the results achieved in the TEAM-2 trial when 77% of the consignments fell within ±4mm of the achieved Hauteur.

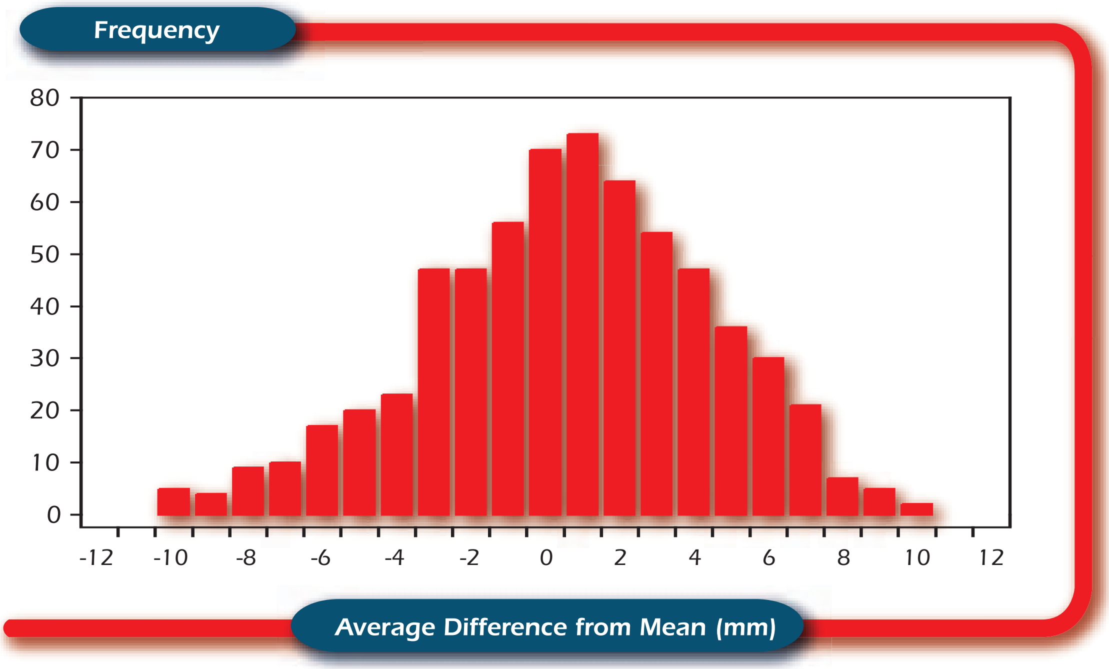

Figure 6.5 Histogram of Differences Between Actual and Predicted (TEAM-3) Hauteur

6.5 Variation Between and Within Individual Mills

As was done in TEAM-2, processing differences between mills have been identified and therefore an important aspect to be emphasised in using the prediction formula is the adjustment of the calculated value of Hauteur to allow for mill differences. Individual mills can comb consistently longer or shorter tops than the values calculated for Hauteur using a general formula. Figure 6.6 plots the distribution of the average differences (i.e. the mill corrections) when the data is analysed on a mill by mill basis. In Figure 6.6, only mills that submitted 10 or more consignments were included, and the proposed TEAM-3 Hauteur formula (Regression 2 from Table 6.4) was used to calculate predicted Hauteur values.

The average of all mill adjustments, 0.2mm, is the same for both TEAM-2 and TEAM-3. The range in mill adjustments was 14.2mm in TEAM-2 (-9.2mm to +5.0mm) but has decreased to 10.8mm in TEAM-3 (-5.2mm to +5.6mm).

As was the case in TEAM-2, the TEAM-3 Steering Committee recommends that mills continually monitor the prediction of Hauteur. As mills collect data on processing consignments, methods to adjust the prediction formula should be implemented. Appendix 3 provides methods by which individual mills can calculate these adjustments and use them as a mill monitoring technique. This Appendix is very similar to Appendix 3 in the TEAM-2 report (1988).

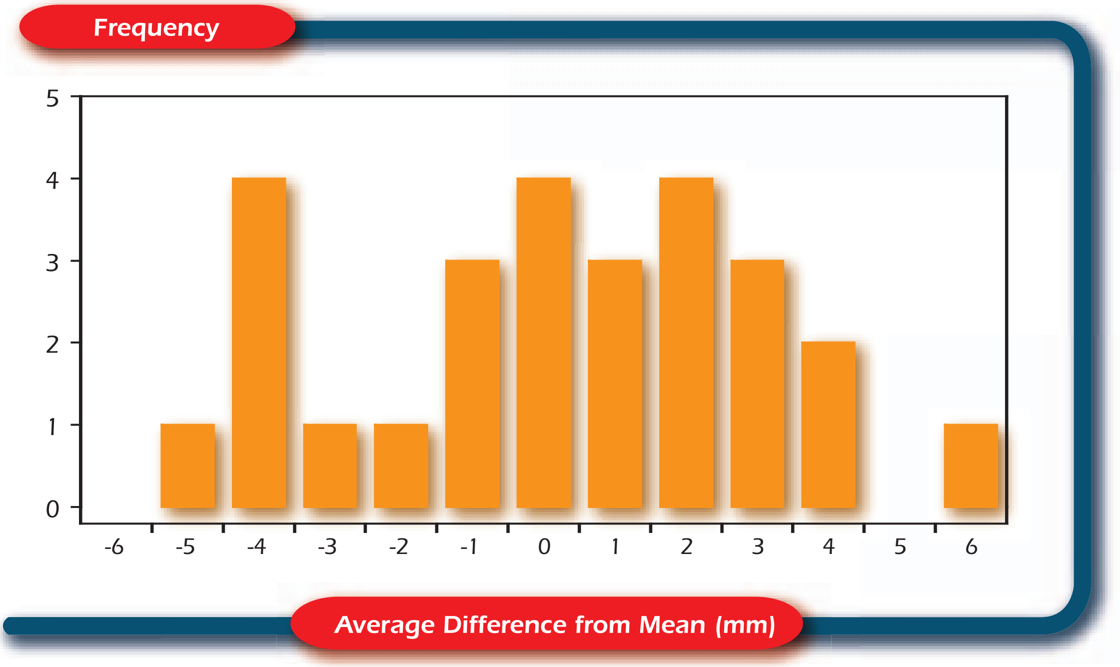

Figure 6.6 Histogram of Differences Between Actual and Predicted Hauteur for Individual Mills

The variability within a mill is largely related to mill quality management. The availability of the TEAM-2 database allowed a comparison between the average predictability of Hauteur for the individual mills in TEAM–2 and the average predictability for the individual mills in TEAM-3. For each mill, the data was analysed so that the variability within that mill could be considered in conjunction with the average mill adjustments.

The statistical method that was used was the calculation of the standard deviation of 'Actual minus Predicted' Hauteur for each mill. There was a marked (30%) reduction from 3.5mm to 2.4mm between the two trials (Table 6.6).

These results demonstrate that there has been a significant improvement in the predictability of Hauteur based on Raw Wool measurements for individual mills in the 16-year period since the publication of the TEAM-2 formulae. The lower SD of the prediction differences implies better mill quality management, further illustrating the benefits of using prediction technology. In addition, improvements in mill quality management may include tighter control of the variation of the raw wool properties in the component Sale Lots.

TABLE 6.6

COMPARISON OF WITHIN-MILL SD OF PREDICTION DIFFERENCES AND MILL FACTORS FOR TEAM-2 AND TEAM-3 DATABASES

	Mill Adjustment (mm)		SD of Prediction Differences (mm)	
	TEAM-2	TEAM-3	TEAM-2	TEAM-3
Average:	0.2	0.2	3.5	2.4
Minimum:	-9.2	-5.2	2.3	1.3
Maximum:	5.0	5.6	4.6	3.7
No. of Mills:	20	27	20	27

6.6 Validation of the TEAM-3 Calibration

The statistics presented in Section 5 are based on using the entire TEAM-3 database to derive a regression formula to predict processing performance. This regression formula has not been validated with additional consignments. A similar approach was taken by the TEAM-2 committee in 1988.

This section examines the validation of the TEAM-3 database by dividing the database into two sets based on a random allocation of consignments. The first set of consignments was allocated to the prediction model and the second set of consignments was used to validate the prediction model. This is therefore a true model development and validation process rather than just a data fitting process.

Using the consignments allocated to the prediction model, the S-Plus (2002) statistical package was used to determine a prediction equation. The coefficients that were determined by this regression analysis are shown in Table 6.7. It is clear that the coefficients are very similar to those obtained when the entire TEAM-3 database was used to derive a calibration equation (Regression 2, Table 6.4).

TABLE 6.7

CALIBRATION OF A RANDOM SUBSET OF THE TEAM-3 DATABASE

Regression	SL	SS	D	VM	M	CVD	CVL
TEAM-3 (Calibration)	0.41	0.26	1.60	- 0.45#	- 0.17	-0.80	-0.35

The # indicates that this coefficient was derived from the TEAM-2 analysis and included here due to the lack of range in VM in the TEAM-3 database.

Once the regression was derived, the equation was used to predict the Hauteur of the remaining validation consignments. The differences between the predicted and actual Hauteur of these validation consignments were then analysed. The average difference between actual and predicted Hauteur was 0.25mm and the standard deviation of these differences was 3.97mm. Given that the mean residual was only 0.25mm and the SD of the differences was relatively low, it can be concluded that the calibration equation is an effective predictor of processing performance. As a comparison, the SD of the differences when the entire TEAM-3 database was used to calculate the prediction equation was 3.84mm. This value includes both within-mill and between-mill effects.

It should be noted that the SD of differences (3.84) is larger than the regression SE (2.49 from Table 6.4). The former represents the error around the average difference whereas the latter represents the error around the regression line. The difference arises from the observed slope between the TEAM-3 residuals and the Actual Values (see Figure 6.4).

6.7 Application of Formulae to Sale Lots

As with TEAM-2, the formulae proposed for TEAM-3 are based on analysis of results from commercial processing consignments. The TEAM-3 consignments contained an average of 40 sale lots with a range from 3 to 254 lots. As the raw wool characteristics of individual sale lots can be outside the average raw wool characteristics of the consignments processed in TEAM-3, application of General Formulae to these sale lots may lead to misleading results. Despite this, the use of the formulae for prediction at the sale lot level can offer mills a useful tool for quality management, as long as results are interpreted in the knowledge that the formulae are based on the performance of consignments, not sale lots.

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7. TEAM-3 DATABASE - PREDICTION OF COEFFICIENT OF VARIATION OF HAUTEUR

The same statistical methods used in Section 6 to analyse the TEAM-3 database for Hauteur were used for the Coefficient of Variation of Hauteur (CVH). Table 7.1 presents the results of the regression analyses for the CVH prediction based on the TEAM-3 database. Regression 1 in Table 7.1 is an analysis using SL, SS, D and M* as a function of CVH. These are the same parameters that formed the basis of the TEAM-2 formula. The coefficients obtained when a regression was conducted on the TEAM-3 database are similar to those obtained in TEAM-2. The main difference is that diameter has a bigger influence on predicted CVH in the TEAM-3 analyses.

The addition of either CVD or MFC to the model resulted in little improvement to the prediction of CVH. However, the addition of CVL (Regression 3) did impact on the prediction with the SE decreasing from 2.69 to 2.62. The TEAM variables together with various combinations of CVL, CVD and MFC were also examined (Regressions 5 to 8).

TABLE 7.1

STATISTICAL ANALYSIS USING CVD, MFC AND CVL TO PREDICT CVH

	Regression	SL	SS	D	M*	CVD	MFC	CVL	SE (%)	R^2
	TEAM-2	0.12	-0.41	-0.35	0.20				2.80	63%
1	TEAM-3	0.18	-0.40	-0.61	0.20				2.69	65%
2	TEAM-3 +CVD	0.23	-0.34	-0.78	0.21	(0.44)			2.68	65%
3	TEAM-3 + CVL	0.31	-0.35	-0.90	0.20			0.42	2.62	67%
4	TEAM-3 + MFC	0.18	-0.40	-0.59	0.20		(0.01)		2.69	65%
5	TEAM-3 + CVL + CVD	0.32	-0.33	-0.95	0.20	(0.14)		0.40	2.62	67%
6	TEAM-3 + CVD + MFC	0.23	-0.34	-0.70	0.21	(0.45)	(0.63)		2.68	65%
7	TEAM-3 + CVL + MFC	0.31	-0.36	-0.77	0.20		(0.03)	0.42	2.62	67%
8	TEAM-3 + CVD + CVL + MFC	0.32	-0.34	-0.80	0.20	(0.16)	(0.04)	0.41	2.62	67%

Note: All coefficients that were not statistically significant are bracketed.

7.1 The Replacement of M* with M in the Prediction of CVH

The TEAM-2 prediction formula for CVH contains an adjusted Mid-Break (M*) parameter. As was examined earlier with Hauteur, the use of M* was compared to the use of the actual Mid-Break percentage (M) for the prediction of CVH. For this analysis Regression 3 from Table 7.1 was used as a benchmark. Table 7.2 shows that the use of M instead of M* results in a minor improvement to the prediction model. As with Hauteur, the use of M can be considered as a possible replacement for M* for the prediction of CVH.

TABLE 7.2

STATISTICAL ANALYSIS USING M INSTEAD OF M*

	Regression	SL	SS	D	M*	M	CVL	SE (%)	R^2
1	TEAM-3 + CVL	0.31	-0.35	-0.90	0.20		0.42	2.62	67%
2	M* replaced by M	0.30	-0.37	-0.88		0.17	0.38	2.58	68%

As the use of M would simplify the TEAM formula, **Regression 2 in Table 7.2 is proposed as the TEAM-3 prediction formula for CVH.** It should be noted that this formula contains a constant term which includes an adjustment associated with individual mill differences. For the entire TEAM-3 database, the adjustment equals 35.6. Therefore, the proposed TEAM-3 formula for CVH is as follows:

CV Hauteur = 0.30L – 0.37S – 0.88D + 0.17M + 0.38CVL + 35.6

The relative importance of each variable in the above table has been estimated from the statistical significance of the regression terms. Table 7.3 provides an estimate for the relative importance of each variable with the most significant factor, Mid-Breaks, given a rating of 100. The next most important variable after Mid-Breaks is Staple Strength (82) followed by Staple Length (66). Table 7.3 also provides a comparison to the TEAM-2 (1988) results where Staple Strength had a rating of 100, followed by Adjusted Mid-Breaks (57).

TABLE 7.3

THE RELATIVE IMPORTANCE OF RAW WOOL CHARACTERISTICS FOR THE PREDICTION OF CVH

Characteristic	Relative Importance TEAM-3	Relative Importance TEAM-2
Mid-Breaks	100	NA
Adjusted Mid-Breaks	NA	57
Staple Strength	82	100
Staple Length	66	33
Diameter	66	22
CV Length	46	NA

Figure 7.1 compares the actual CVH values with the residual CVH. The residual CVH was calculated by subtracting the predicted CVH from the actual CVH. The predicted CVH was calculated using the TEAM-3 CVH regression formula which has been proposed above.

Figure 7.2 plots the differences between actual and predicted CVH and shows that 86% of the consignments fell within ±4% of the mean. This was comparable with the 83% that fell within this range in the TEAM-2 trial.

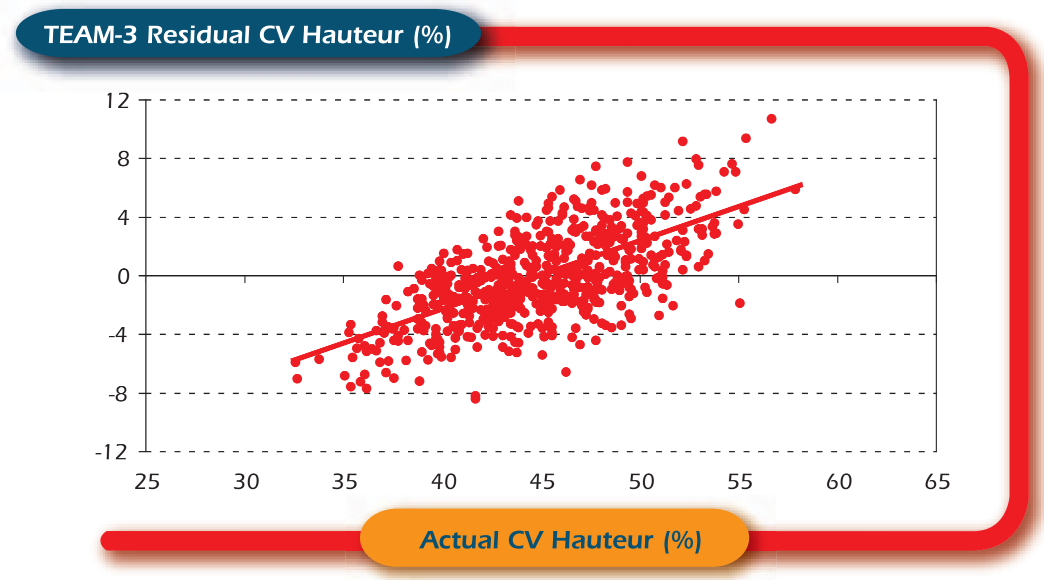

Figure 7.1 Relationship between Actual CVH and TEAM-3 Residual CVH

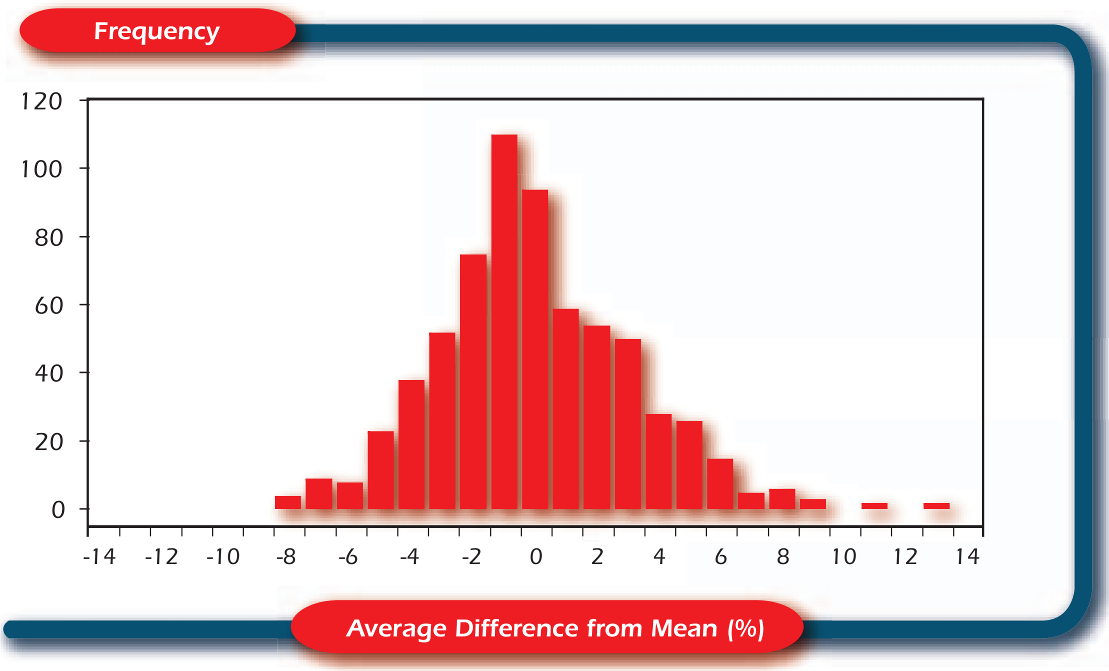

Figure 7.2 Histogram of Differences Between Actual and Predicted (TEAM-3) CVH

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8. TEAM-3 DATABASE - PREDICTION OF ROMAINE

The same statistical methods used in Sections 6 and 7 to analyse the TEAM-3 database for Hauteur and CVH were used for Romaine. Table 8.1 presents the results of the regression analyses for the Romaine prediction based on the TEAM-3 database. Regression 1 in Table 8.1 is an analysis using SL, SS, D and VM as a function of Romaine. These are the same parameters that formed the basis of the TEAM-2 formula. The coefficients obtained when a regression was conducted on the TEAM-3 database are similar to those obtained in TEAM-2. The main differences are that diameter has a bigger influence on predicted Romaine in the TEAM-3 analysis and VM has less impact. The reduced influence of VM may be a reflection of the relatively narrow range of VM in the TEAM-3 database. This was discussed for Hauteur in Section 6. Despite the reduced influence, it is important to note that VM does have a statistically significant influence on the TEAM-3 processing prediction model for Romaine. This was not the case for Hauteur.

The addition of CVD, MFC or CVL to the model resulted in little improvement to the prediction of Romaine. The TEAM variables together with various combinations of CVL, CVD and MFC were also examined.

TABLE 8.1

STATISTICAL ANALYSIS USING CVD, MFC AND CVL TO PREDICT ROMAINE

	Regression	SL	SS	D	VM	CVD	MFC	CVL	SE (%)	R^2
	TEAM-2	-0.11	-0.14	-0.35	0.94				1.50	76%
1	TEAM-3	-0.13	-0.18	-0.63	0.78				1.31	77%
2	TEAM-3 +CVD	-0.10	-0.14	-0.73	0.82	(0.23)			1.31	77%
3	TEAM-3 + CVL	-0.08	-0.16	-0.74	0.69			0.17	1.29	78%
4	TEAM-3 + MFC	-0.13	-0.17	-0.80	0.77		(-0.04)		1.31	77%
5	TEAM-3 + CVL + CVD	-0.07	-0.14	-0.77	0.72	(0.10)		0.16	1.29	78%
6	TEAM-3 + CVD + MFC	-0.10	-0.14	-0.86	0.81	(0.20)	(-0.03)		1.31	77%
7	TEAM-3 + CVL + MFC	-0.08	-0.15	-0.86	0.69		(-0.03)	0.17	1.29	78%
8	TEAM-3 + CVD + CVL + MFC	-0.07	-0.17	-0.88	0.71	(0.08)	(-0.03)	0.16	1.29	78%

Note: All coefficients that were not statistically significant are bracketed.

As the addition of CVD, CVL or MFC did not impact on the prediction model for Romaine, **Regression 1 in Table 8.1 is proposed as the TEAM-3 prediction formula for Romaine.** It should be noted that this formula contains a constant term which includes an adjustment associated with individual mill differences. For the entire TEAM-3 database, the adjustment equals 38.6. Therefore, the proposed TEAM-3 formula for Romaine is as follows:

$$\textbf{Romaine} = -0.13L - 0.18S - 0.63D + 0.78V + 38.6$$

The relative importance of each variable in the above table has been estimated from the statistical significance of the regression terms. Table 8.2 provides an estimate for the relative importance of each variable with the most significant factor, Mean Fibre Diameter, given a rating of 100. The next most important variable is Staple Strength (79) followed by Staple Length (69). Table 8.2 also provides a comparison to the TEAM-2 (1988) results where Vegetable Matter Base had a rating of 100, followed by Staple Strength (63).

TABLE 8.2

THE RELATIVE IMPORTANCE OF RAW WOOL CHARACTERISTICS FOR THE PREDICTION OF ROMAINE

Characteristic	Relative Importance TEAM-3	TEAM-2
Diameter	100	41
Staple Strength	79	63
Staple Length	69	51
Vegetable Matter	66	100

Figure 8.1 provides a comparison of the actual Romaine and the Residual Romaine. The Residual Romaine was calculated by subtracting the predicted Romaine from the actual Romaine. The predicted Romaine was calculated using the above proposed TEAM-3 Romaine regression formula.

Figure 8.2 plots the differences between actual and predicted Romaine and shows that 88% of the consignments fell within ±2% of the mean. This was comparable with the 84% that fell within this range in the TEAM-2 trial.

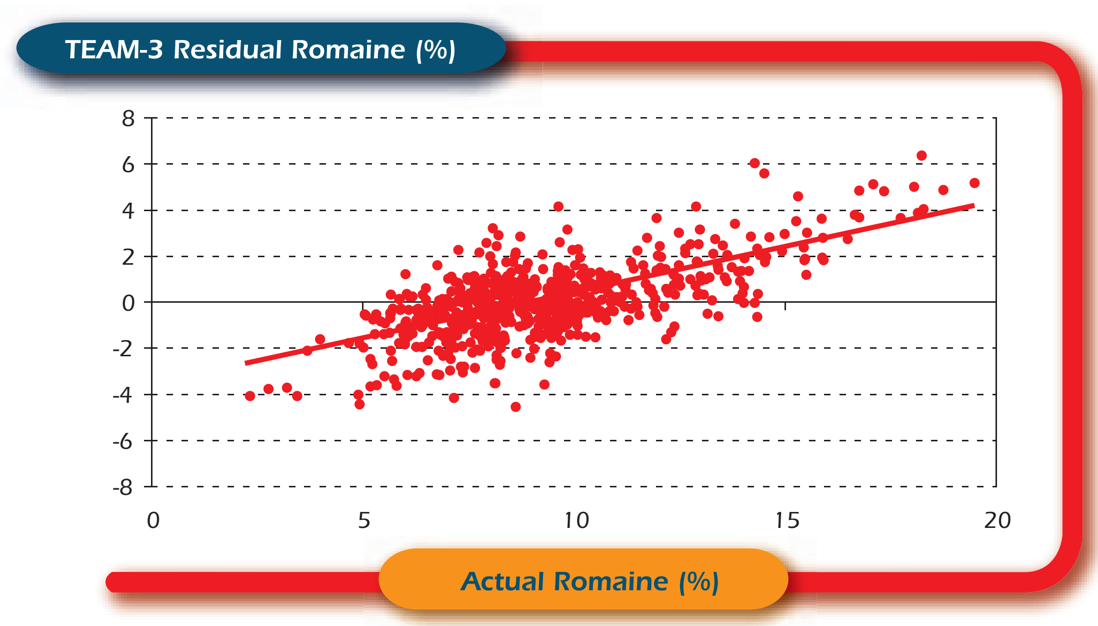

Figure 8.1 Relationship between Actual Romaine and TEAM-3 Residual Romaine

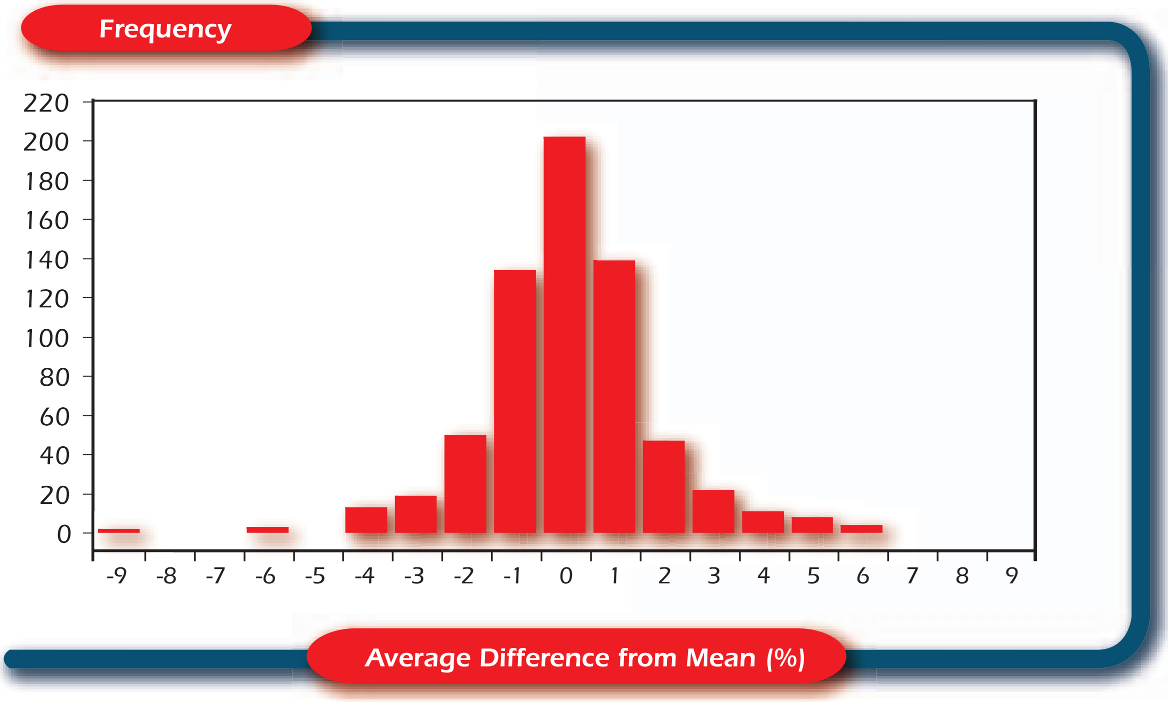

Figure 8.2 Histogram of Differences Between Actual and Predicted (TEAM-3) Romaine

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9. CONCLUSIONS AND RECOMMENDATIONS

This report summarises the final analysis of the TEAM-3 database. The TEAM-3 Steering Committee is able to report that, with the exception of VM, the TEAM-2 parameters (SL, SS, MFD, and M*) are still applicable to processing prediction models. It is shown that processing performance has improved since the late 1980's. Mills are producing tops with Hauteur values, on average, 5.1mm longer than is predicted using the TEAM-2 general formula and greater differences occur as the Hauteur increases above 75mm. In addition, mills are producing tops with CVH values, on average, 2.5% less than predicted by TEAM-2 and Romaine values 2.1% greater than predicted.

Mills also achieve more consistent, predictable results with lower standard deviations between actual and predicted Hauteur than in TEAM-2.

The regression analyses for Hauteur, CVH and Romaine have shown that it is possible to calculate new General Formulae for each of these parameters, although they would be similar to the TEAM-2 General Formulae published in 1988. The addition of CVD and CVL provides small improvements to the prediction of Hauteur and the addition of CVL provides a small improvement to the prediction of CVH. Similarly, the use of M instead of M* makes little change to any prediction model. Based on the regression analysis of the TEAM-3 database and the additional analyses on the influence of VM Base, the inclusion of the TEAM-2 coefficient for VM in a TEAM-3 prediction model for Hauteur is recommended. It has also been identified that there is no improvement in processing prediction if MFC is added to the prediction model.

The TEAM-3 Steering Committee recommends that the industry consider the following three options:

Option 1. Retain the existing TEAM-2 formulae in the IWTO Staple Test Regulations.

Advantages of Option 1:

- The TEAM-3 trial has shown that the TEAM-2 formula is robust, and if changes were made to the formulae they would be small and would not improve processing predictability significantly.
- The observed differences can be easily accommodated with the TEAM-2 recommended techniques for calculating and applying mill adjustment factors.
- It is the easiest solution to implement with minimal disruption.
- The TEAM-2 formulae are simple to apply and understand.
- No changes are required to existing databases and computer programs around the world.
- No changes are required for Letters of Credit, specifications and contract limits.

Disadvantages of Option 1:

- General processing conditions have changed and actual processing performance will differ from predicted processing performance (eg. average of +5.1mm for Hauteur).
- A database as comprehensive as that complied for TEAM-3 is unlikely to be available in the near future due to the cost of assembling it.
- The use of M* in the TEAM-2 formulae makes it difficult to calculate an average Hauteur when a number of sale lots are combined.

Option 2. **Introduce the following TEAM-3 formulae into the IWTO Staple Test Regulations as a replacement for the TEAM-2 formulae.**

$$\text{Hauteur} = 0.43L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 21.8$$

$$\text{CV Hauteur} = 0.30L - 0.37S - 0.88D + 0.17M + 0.38CVL + 35.6$$

$$\text{Romaine} = -0.13L - 0.18S - 0.63D + 0.78V + 38.6$$

Advantages of Option 2:

- The new formulae will better reflect current commercial processing conditions.
- The new formulae includes additional measurement data (CVL and CVD) that provide a small benefit to the prediction model.
- New formulae would better facilitate any future adjustments (eg 'Atypical' Sale Lots) without the need to repeat a processing trial of this magnitude.
- New formulae would remove the complications caused by the use of M* rather than M.

Disadvantages of Option 2:

- The introduction of new formulae would cause significant disruption to current systems in terms of databases, software, contract limits, Letters of Credit etc.
- There would be a requirement for an extensive education campaign.
- The use of more 'minor' terms may encourage the use of inappropriately tight specifications for these measurements. This may lead to more difficulty in purchasing for only very small gains in processing prediction.

Option 3. **Include both the TEAM-2 formulae and TEAM-3 formulae in the IWTO Staple Test Regulations.**

Advantages of Option 3:

- Will allow mills to choose the formulae that best suit their requirements.
- Is consistent with the IWTO Core Tests Regulations which provide different formulae for calculating Commercial Yield.

Disadvantage of Option 3:

- Two sets of processing prediction formulae is likely to create some confusion.
- The use of M* in the TEAM-2 formulae makes it difficult to calculate an average Hauteur when a number of sale lots are combined.

10. REFERENCES

Allen, D.J. (1991). Variability of Fibre Length in Tops. *International Wool Textile Organisation. Commercial Technology Forum.* Nice Meeting, November 1999 Report CTF 11.

Cilliers, W.C., Robinson, G.A. and Slinger, R.I. (1968). The Processing Characteristics of South African Wools. Part IV: High Crimp Wools. SAWTRI Tech. Rep. No 110.

Douglas, S.A.S. and Couchman, R.C. (1997). Industry Review of the TEAM Prediction Formulae. *International Wool Textile Organisation. Woolgrowers, Traders & Early Processors Committee.* Nice Meeting, December 1997.

Haigh, M. (2002). Fibre to fabric. Fibre Crimp and Fibre Curvature: Fibre to Fabric Seminar, February 2002.

Hunter, L. and Gee, E. (1980), The Effect of Staple Crimp, Resistance to Compression and Fibre Diameter and Length Characteristics on the Physical Properties of Wool Worsted Yarns. *Proc. 6th Quinquennial Int. Wool Textile Res. Conf.*, Pretoria, 1980, Vol II.

IWTO-DTM-60-01, The Woolmark Company, UK.

Kurdo, K.O.A., Whiteley, K.J. and Smith, L.J. (1984) The Influence of Resistance to Compression on the Processing Performance of Superfine Wools Part 1: Topmaking, *International Wool Textile Organisation. Technical Committee.* Tokyo Meeting, May 1984 Report 12.

Lamb, P. R. (2000). The Impact of CV(D) and Crimp or Curvature on Hauteur and Romaine. International *Wool Textile Organisation. Commercial Technology Forum.* Christchurch Meeting, May 2000 Report CTF 02.

Lindsay, A.R., Marler, J.W., and Jackson, M.A. (2003). TEAM-3 Processing Trial – November 2003 Update. *International Wool Textile Organisation. Commercial Technology Forum.* Dubrovnik Meeting, November 2003.

Lindsay, A.R., Marler, J.W., and Jackson, M.A. (2002a). Preliminary Analysis of TEAM-3 Database. *International Wool Textile Organisation.* Raw Wool Group. Barcelona Meeting, May 2002 Report 4.

Lindsay, A.R., Marler, J.W., and Jackson, M.A. (2002b). TEAM-3 Progress Report (December 2002). *International Wool Textile Organisation. Commercial Technology Forum.* Nice Meeting, December 2002 Report CTF 02.

Marler, J.W. (1985), The Influence of Resistance to Compression on Early Stage Processing , Standards Association of Australia, TX12/85-25, 1.

Peterson, A. (2002). What is fibre curvature? Fibre Crimp and Fibre Curvature: Fibre to Fabric Seminar, February 2002.

S-Plus for Windows (2002). Professional Edition, Insightful Corp.

Stevens, D and Mahar, T.J. (1995), The Beneficial Effects of Low Crimp in Worsted Processing and on Fabric Properties and Fabric Handle, 9th International Wool Textile Research Conference, Biella, V,134.

Stevens, D. and Crowe, D.W. (1994), Style and Its Processing Effects, WoolSpec 94, E1.

TEAM-3 Steering Committee (2004). TEAM-3 Processing Trial – Final Report. *International Wool Textile Organisation. Raw Wool Group.* Evian Meeting, May 2003 Report RWG 02.

TEAM-3 Steering Committee (2003). TEAM-3 Processing Trial – May 2003 Update. *International Wool Textile Organisation. Commercial Technology Forum.* Buenos Aries Meeting, May 2003 Report CTF 04.

Trials Evaluating Additional Measurement (1988). Report to the Raw Wool Measurement Research Advisory Committee of the Australian Wool Corporation, December 1988.

Turpie, D.W.F., and Shiloh, M. (1973). The Processing Characteristics of South African Wools. Part V: Properties of Merino Wool Types Varying in Staple Crimp. SAWTRI Tech. Rep. No 189.

Vizard, A.L., and Hansford, K.A. (1999). Use of Objective Measurements in Breeding Programs for Merino Sheep Leads to Improved Topmaking Performance. *International Wool Textile Organisation. Commercial Technology Forum.* Florence Meeting, June 1999 Report CTF 01.

APPENDIX 1
STANDARD PROFORMA FOR COLLECTION OF CONSIGNMENT DATA

TEAM-3 PROJECT: CONSIGNMENT NOMINATION

A. IDENTIFICATION

Participating Company Name ....

Consignment / Batch Reference ....

Date of Combing ....

Processing Mill ....

B. GREASY WOOL TEST RESULTS

Test Number of IWTO Combined Certificates* – Yield/Micron ....

– Length/Strength ....

* Where an IWTO Combined Certificate has not been created for the consignment by AWTA Ltd, **please attach a list of the individual AWTA Ltd Test Numbers** for both Core Test and Staple Measurement Certificates comprising the consignment. Or, for wool of non- Australian origin, attach copies of the relevant NZWTA Ltd or WTB-SA Certificates.

C. CONSIGNMENT WEIGHT AND OUTSOURCED WOOL

Total Bales	....	Bales
Greasy Weight	....	Kg
Tare	....	Kg
Net Weight	....	Kg
Outsorts (if any)	....	Greasy kg

NOTE: It is preferable that there should be no sorting of wools and/or removal of bales unless considered to be absolutely necessary. If sorting exceeds 1% of the greasy weight, it is unlikely that a valid greasy wool test/combing comparison can be made. So, the amount of any outsorts should be determined accurately and the reasons for removal noted below.

Reason for Outsorts:...

Please attach the Processing Report (either the Mills own combing report, or the proforma TEAM-3 Processing Report) to this Nomination form, then despatch it and the required top samples to:

AWTA Ltd
Attn: Andrew Lindsay, Sampling Operations Manager – NSW & Qld
Cnr Byron and Military Roads
GUILDFORD, NSW 2161
AUSTRALIA

Fax number: +61 (0)2 9892 3195
E-mail address: andrew.lindsay@awta.com.au

TEAM-3 PROJECT: PROCESSING REPORT

Note: The Mill Combing Report and Top Test Results can be used instead of this proforma, if they provide the equivalent information.

A. IDENTIFICATION

Participating Company Name ....

Consignment / Batch Reference ....

Date of Combing ....

Processing Mill ....

B. PROCESSING DATA

* Please indicate whether cardwastes have been recycled YES / NO

Results by item (as applicable)		Nett kg	%
- Tops, conditioned		....	....
- Noils, conditioned		....	....
- Other wastes		....	....
Romaine (Noil)		..................%	
<u>IF AVAILABLE</u>			
Combing Line Reference	- Scouring Line:	....	
	- Carding / Combing:	....	

C. MILL TEST RESULTS

Conditioning:	Top moisture regain	.... %
	Noil moisture regain	.... %
Fatty Matter:	Top, total fatty matter (on dry fat free weight)	.... %
	Solvent used	....
Top Length:	Almeter Hauteur	.... mm
	CV Hauteur	.... %
	% < 25mm	.... %
	Length (Hauteur) > 5%	.... mm

NOTE: If Almeter results are not available, please provide alternative measurements clearly noting the method used.

Top Fineness: *(Please supply all available results)*

	LASERSCAN	OFDA	Airflow	
Mean Fibre Diameter	....	....	....	micron (μm)
Coefficient of Variation of Diameter	....	....		%
Fibres <30 micron	....	....		%

D. OTHER TESTS OR PROCESSING INFORMATION (if considered relevant):

....

....

....

E. SAMPLING FOR TESTING AND FUTURE REFERENCE

Tops:

A minimum of 5 samples of top, each 1.2 metres in length, are required from each processing batch. These samples will be retained by AWTA Ltd and used as a reference sample should there be any discrepancy in results. Each top sample should be taken sequentially throughout combing so that they are representative of the whole consignment. The most practical method of sampling is to take 2 lengths of top when sampling for in-house mill testing.

Each sample should be identified by the name of the participant, the consignment reference number and a suffix to indicate the production sequence.

NOTE: 1. The sampling requirements are based on those set out in the IWTO Regulations for the testing of Wool Slivers for Mean Fibre Diameter & Mean Fibre Length.

2. Each 1.2 metre length of sample sliver should be twisted as per the requirements of Section 6.1.1 (i) of IWTO-17-85 or wrapped onto formers.

APPENDIX 2
RELATIONSHIP BETWEEN MEAN FIBRE CURVATURE AND RESIDUAL HAUTEUR FOR CONSIGNMENTS OF DIFFERENT MEAN FIBRE DIAMETER

In an attempt to remove any potential influence due to the strong correlation (R = -0.91) between MFC and MFD (see Appendix 4), the MFC relationship of all consignments with a diameter of 16.0µm to 18.0µm was examined (see Figure A2.1). This was repeated for wool of diameter 18.1µm to 20.0µm (see Figure A2.2), and 20.1µm and greater (see Figure A2.3).

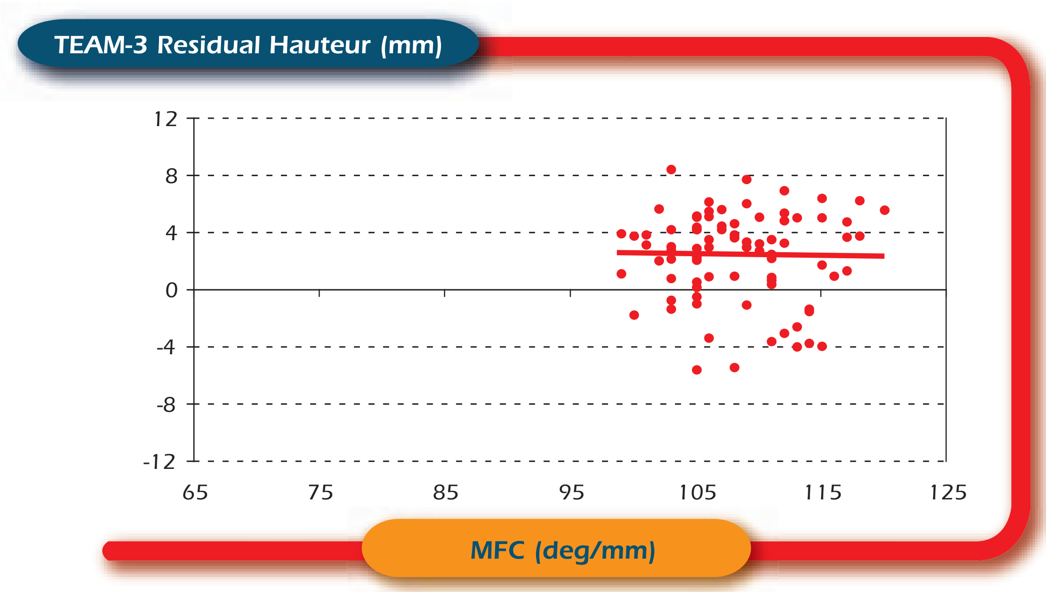

Figure A2.1 Relationship between MFC and TEAM-3 Residual Hauteur for Consignments 16.0µm to 18.0µm

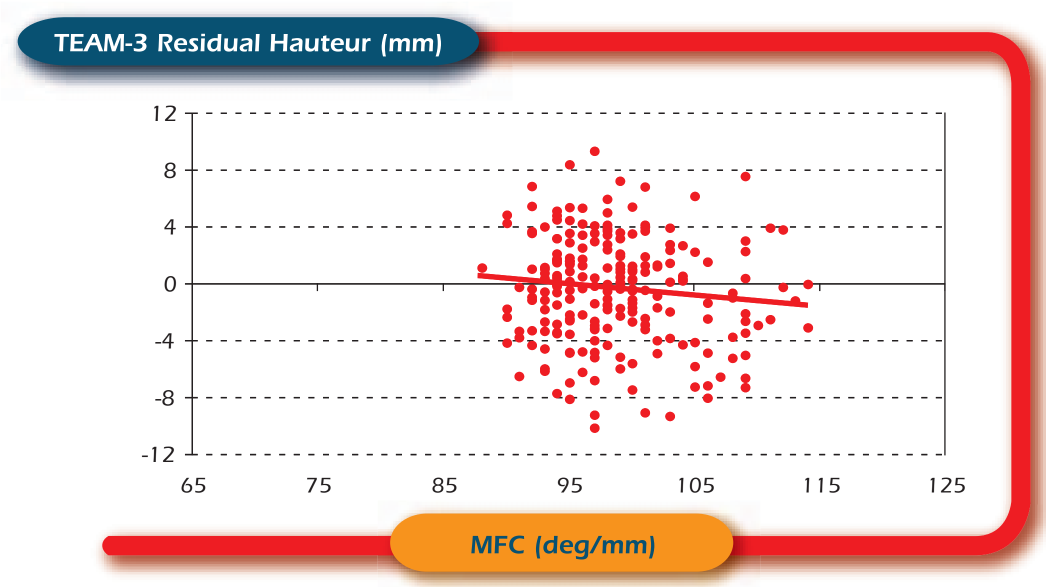

Figure A2.2 Relationship between MFC and TEAM-3 Residual Hauteur for Consignments 18.1µm to 20.0µm

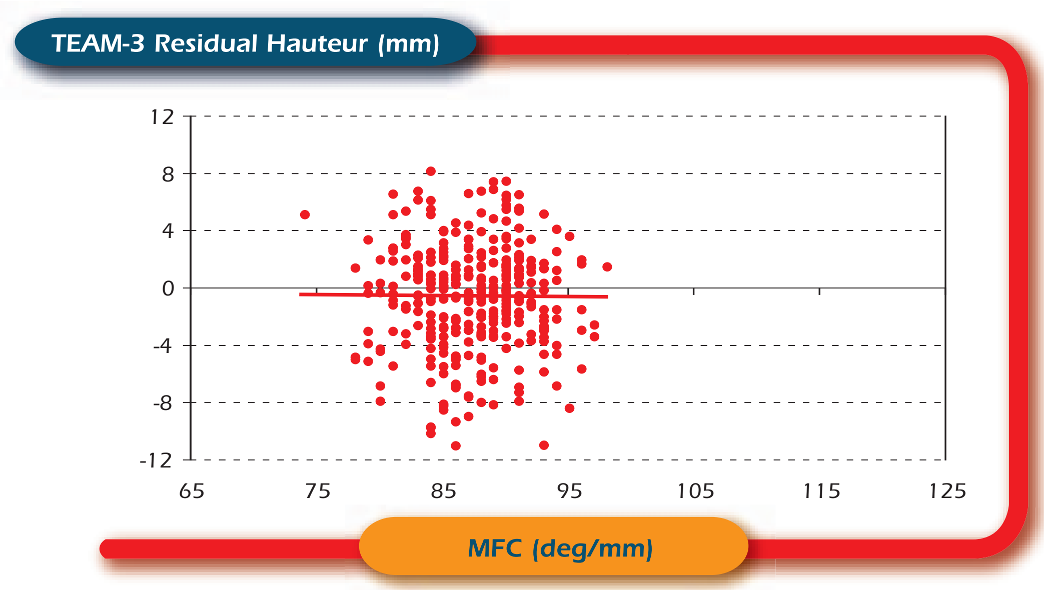

Figure A2.3 Relationship between MFC and TEAM-3 Residual Hauteur for Consignments 20.1µm and greater

The three figures above show that there is no relationship between the TEAM-3 Residual Hauteur and MFC. This gives further weight to the conclusion that, for the processing consignments submitted as part of the TEAM-3 trial, the inclusion of MFC does not improve the prediction of Hauteur.

APPENDIX 3
ADJUSTMENT OF THE GENERAL FORMULAE FOR A SPECIFIC MILL

As indicated in Section 6.4 of this report, the performance of a general formula is influenced by both within and between mill variation. This Appendix provides techniques for mills to adjust the General Formulae to suit their individual situation. It is important that before making an attempt to adjust the TEAM General Formulae, the mill's processing performance is stable. If a mill's performance is changing during the adjustment period then it will be continually making adjustments to the formulae to simply follow the trends.

This appendix provides an example of how to calculate a mill specific formula for Hauteur. The same techniques can be used to create mill specific formulae for CVH and Romaine.

A3.1 Calculation of a Mill-Specific Constant

A mill should select the most recent batch of processing consignments that are available. This will preferably be a minimum of 20 consignments, of which the individual sale lot components should all have been tested for Yield & Micron and Length & Strength.

The first step is to calculate the Hauteur (H_i) from the data for each consignment (i) using the prediction formula. In this example, we have used the proposed TEAM-3 formula for Hauteur:

$$H_i = 0.43L_i + 0.35S_i + 1.38D_i - 0.15M_i - 0.45V_i - 0.59CVD_i - 0.32CVL_i + 21.8$$

For each consignment (i), the difference (C_i) between the actual Hauteur (H_a) and the predicted Hauteur (H_i) should be calculated:

$$C_i = H_a - H_i$$

The results for a theoretical mill are presented Table A3.1 where the average difference between actual and predicted Hauteur is 1.7mm. This is referred to as the mill adjustment.

The next step is establish the presence or absence of trends over time by preparing a graph of the differences between the actual and predicted Hauteur against processing order (Figure A3.1). During the processing time period for these 20 consignments, no obvious trend is evident.

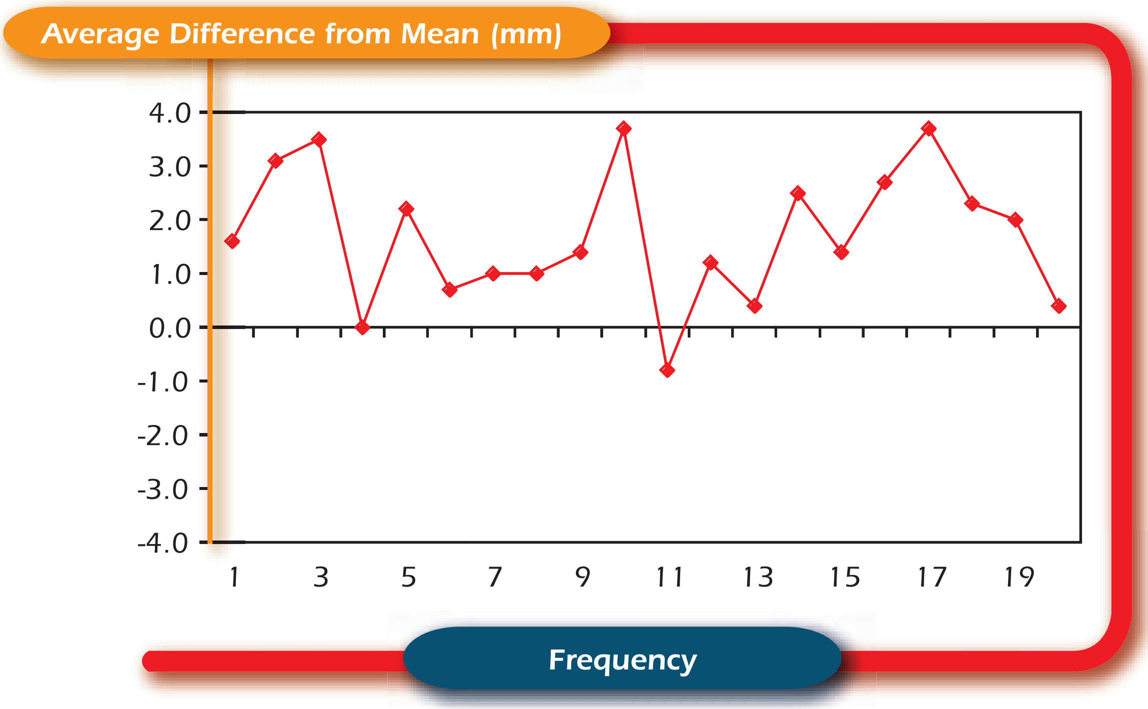

Figure A3.1 Hauteur Differences: Actual Predicted Hauteur

TABLE A 3.1

COMPARISON BETWEEN ACTUAL AND PREDICTED HAUTEUR FOR A THEORETICAL MILL

Actual Hauteur (H_a) (mm)	Predicted Hauteur (H_m) (mm)	$C_i = H_a - H_i$ (mm)
61.6	60.0	1.6
79.1	76.0	3.1
61.5	58.0	3.5
80.8	80.8	0.0
64.2	62.0	2.2
68.2	67.5	0.7
77.5	76.5	1.0
79.3	78.3	1.0
62.6	61.2	1.4
59.0	55.3	3.7
66.0	66.8	-0.8
73.9	72.7	1.2
58.1	57.7	0.4
66.5	64.0	2.5
71.4	70.0	1.4
70.7	68.0	2.7
67.3	63.6	3.7
74.3	72.0	2.3
67.0	65.0	2.0
77.9	77.5	0.4
69.3	**67.6**	**1.7**

The mill adjustment shown in Table A3.1 is 1.7mm. The TEAM-3 formula for Hauteur contains a constant of 21.8. A mill specific constant can be calculated by adding the average mill adjustment to the general formula constant (i.e. 21.8 + 1.7 = +23.5). Therefore, the specific Hauteur (H_m) formula for this theoretical mill can be written as:

$$H_m = 0.43L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 23.5$$

The recalculated Hauteurs based on the mill specific formula are compared to the actual Hauteurs in Table A3.2. The average difference between actual and predicted Hauteur based on the adjusted mill Hauteur formula is 0.0mm. These differences are presented in Figure A3.2 and A3.3.

TABLE A 3.2

COMPARISON BETWEEN ACTUAL AND PREDICTED HAUTEUR USING MILL SPECIFIC FORMULA

Actual Hauteur (H_a) (mm)	Predicted Hauteur (H_m) (mm)	$C_i = H_a - H_m$ (mm)
61.6	61.7	-0.1
79.1	77.7	1.4
61.5	59.7	1.8
80.8	82.5	-1.7
64.2	63.7	0.5
68.2	69.2	-1.0
77.5	78.2	-0.7
79.3	80.0	-0.7
62.6	62.9	-0.3
59.0	57.0	2.0
66.0	68.5	-2.5
73.9	74.4	-0.5
58.1	59.4	-1.3
66.5	65.7	0.8
71.4	71.7	-0.3
70.7	69.7	1.0
67.3	65.3	2.0
74.3	73.7	0.6
67.0	66.7	0.3
77.9	79.2	-1.3
69.3	**69.3**	**0.0**

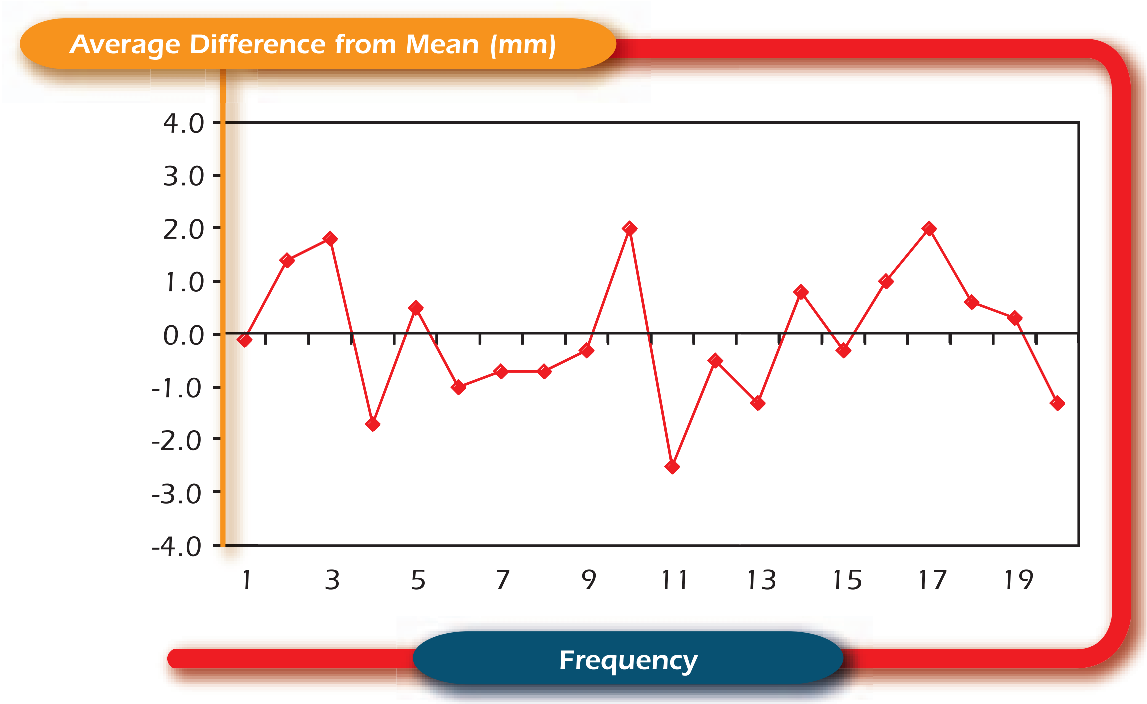

Figure A3.2 Hauteur Differences: Actual Predicted Hauteur when Mill Adjusted Formula is Applied

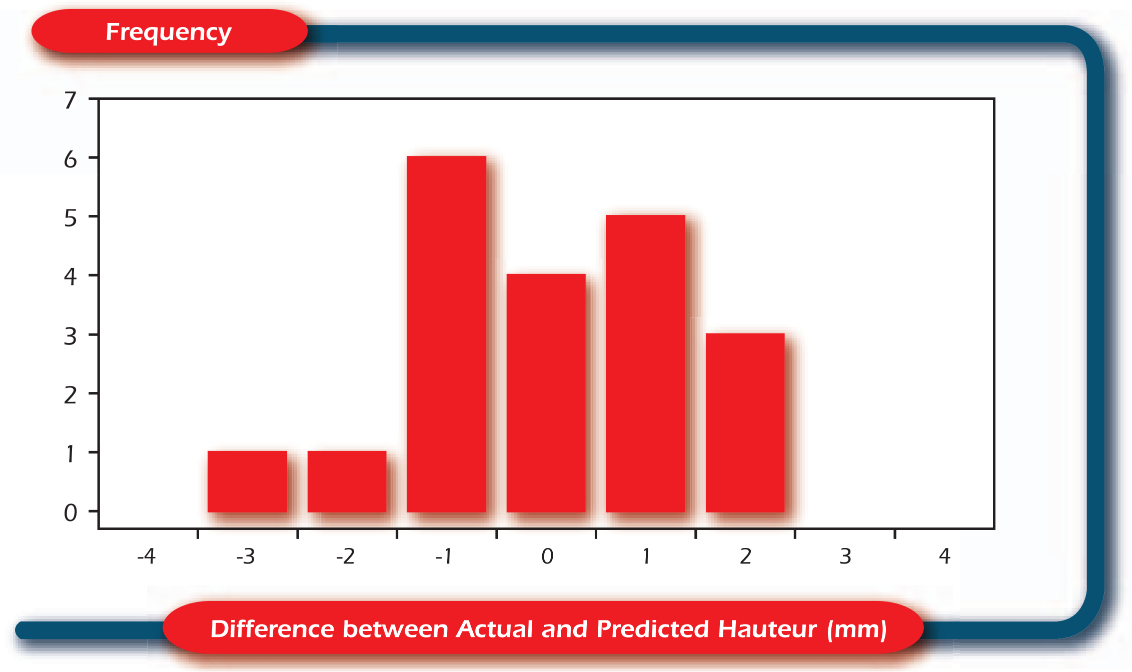

Figure A3.3 Histogram of Differences: Actual Predicted Hauteur when Mill Adjusted Formula is Applied

A3.2 Calculation of Mill-Specific Coefficients and Terms

Once more data is available, alternative techniques can be used to create a mill specific Hauteur formula. The first step to modify the formula beyond a simple adjustment is to examine the relationship of the differences between the actual and predicted Hauteurs for each of the major raw wool characteristics. This should only be attempted when a database of 100 to 200 consignments is obtained. This database should be representative of the wool types the mill expects to process in the future.

The first step is to identify obvious trends by graphing the differences between actual and predicted Hauteur for the measured raw wool characteristics, including those used in the general formula. If a trend is identified, a further adjustment procedure can be conducted.

As an example from a theoretical mill, Figure A3.4 shows the differences between actual and predicted Hauteur plotted against Staple Length (mm). An obvious trend is evident in this graph in that as SL increases, the differences between actual and predicted Hauteur become larger. It would appear that an adjustment to the formula is required for this mill based on these results. One technique that can be used to achieve this is to determine a linear regression equation of the differences. This equation is shown on Figure A3.4. This equation can be added to the previously adjusted Hauteur formula so that the fully adjusted general formula for this mill would be:

$$H_m = 0.43L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 21.8 + (0.15L - 10.7)$$

$$H_m = 0.58L + 0.35S + 1.38D - 0.15M - 0.45V - 0.59CVD - 0.32CVL + 11.1$$

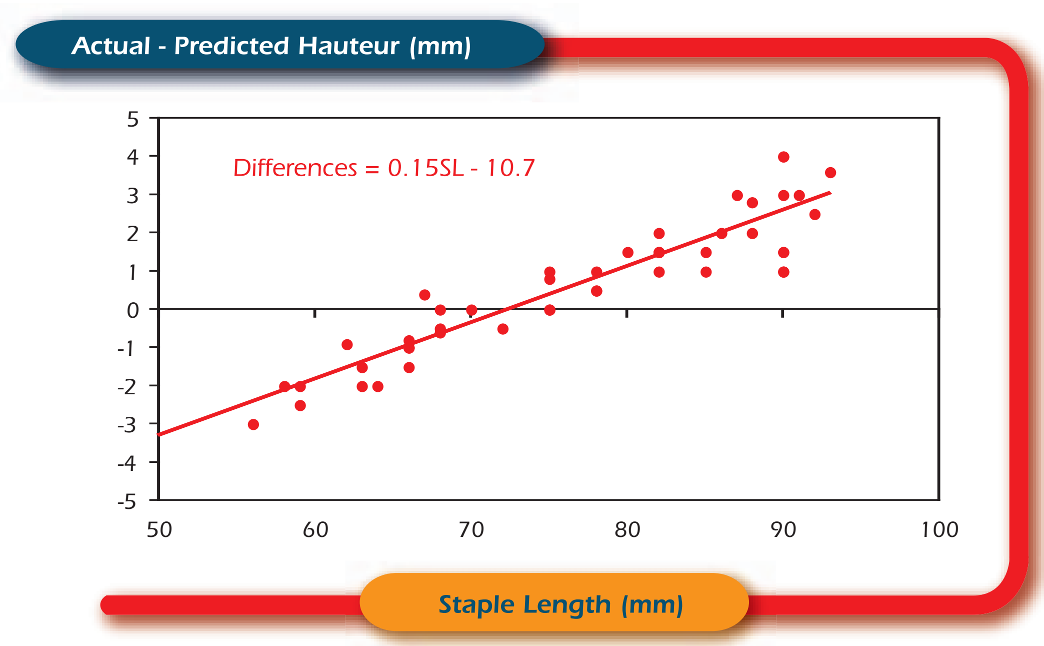

Figure A3.4 Hauteur Differences as a Function of Vegetable Matter Base

A3.3 Adjustment of the Hauteur Formula for Specific Requirements

As more data is obtained, alternative techniques can be considered that group the differences between actual and predicted Hauteur according to a variety of different factors. These factors may include wool type, Vegetable Matter type etc. This technique can be used as an alternative to that described above when there are a number of non-measurable parameters that may influence processing results.

It can also be applied to separate processing lines within the same mill to establish separate adjustments for each line and to account for differences between the lines.

Appendix 4

Correlation Matrix for TEAM-3 Data Base

	WB	MFD	CVD	CF	MFC	VMB	SL	CVL	SS	MID	Romaine	FEFD	FECF	Top MFD	Top CVD	Top CF	Hauteur	CVH
WB	1.00	-0.18	-0.75	0.29	0.33	-0.43	0.11	-0.50	0.48	-0.04	-0.24	-0.21	-0.01	-0.17	-0.58	0.25	0.14	-0.03
MFD	-0.18	1.00	0.16	-0.89	-0.91	0.05	0.73	-0.13	0.04	-0.09	-0.68	0.97	-0.02	0.99	0.43	-0.91	0.65	-0.01
CVD	-0.75	0.16	1.00	-0.34	-0.29	0.15	-0.05	0.51	-0.54	-0.02	0.16	0.20	0.03	0.14	0.77	-0.27	-0.18	0.14
CF	0.29	-0.89	-0.34	1.00	0.77	-0.10	-0.55	-0.03	0.01	0.10	0.51	-0.87	0.03	-0.88	-0.47	0.97	-0.52	0.04
MFC	0.33	-0.91	-0.29	0.77	1.00	-0.08	-0.70	0.03	0.15	0.01	0.57	-0.90	0.00	-0.91	-0.57	0.80	-0.55	-0.09
VMB	-0.43	0.05	0.15	-0.10	-0.08	1.00	-0.21	0.43	0.01	0.05	0.29	0.04	-0.01	0.06	0.12	-0.10	-0.01	-0.19
SL	0.11	0.73	-0.05	-0.55	-0.70	-0.21	1.00	-0.47	-0.22	0.07	-0.67	0.73	0.02	0.73	0.25	-0.59	0.57	0.29
CVL	-0.50	-0.13	0.51	-0.03	0.03	0.43	-0.47	1.00	-0.11	0.12	0.44	-0.10	0.03	-0.13	0.30	0.02	-0.34	0.04
SS	0.48	0.04	-0.54	0.01	0.15	0.01	-0.22	-0.11	1.00	-0.27	-0.20	-0.02	-0.07	0.05	-0.49	0.00	0.29	-0.53
MID	-0.04	-0.09	-0.02	0.10	0.01	0.05	0.07	0.12	-0.27	1.00	0.10	-0.04	0.03	-0.10	-0.02	0.10	-0.33	0.54
Romaine	-0.24	-0.68	0.16	0.51	0.57	0.29	-0.67	0.44	-0.20	0.10	1.00	-0.67	0.02	-0.68	-0.14	0.55	-0.65	0.06
FEFD	-0.21	0.97	0.20	-0.87	-0.90	0.04	0.73	-0.10	-0.02	-0.04	-0.67	1.00	-0.03	0.97	0.46	-0.88	0.63	0.03
FECF	-0.01	-0.02	0.03	0.03	0.00	-0.01	0.02	0.03	-0.07	0.03	0.02	-0.03	1.00	-0.02	0.00	0.03	-0.05	0.04
Top MFD	-0.17	0.99	0.14	-0.88	-0.91	0.06	0.73	-0.13	0.05	-0.10	-0.68	0.97	-0.02	1.00	0.43	-0.91	0.65	-0.02
Top CVD	-0.58	0.43	0.77	-0.47	-0.57	0.12	0.25	0.30	-0.49	-0.02	-0.14	0.46	0.00	0.43	1.00	-0.49	0.04	0.19
Top CF	0.25	-0.91	-0.27	0.97	0.80	-0.10	-0.59	0.02	0.00	0.10	0.55	-0.88	0.03	-0.91	-0.49	1.00	-0.55	0.05
Hauteur	0.14	0.65	-0.18	-0.52	-0.55	-0.01	0.57	-0.34	0.29	-0.33	-0.65	0.63	-0.05	0.65	0.04	-0.55	1.00	-0.50
CVH	-0.03	-0.01	0.14	0.04	-0.10	-0.19	0.29	0.04	-0.53	0.54	0.06	0.03	0.04	-0.02	0.19	0.05	-0.50	1.00

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